KYOVA Model Documentation and User's Manual

Introduction

Kimley-Horn and Associates, Inc. (KHA) is developing a new travel demand model with a validated base year of 2010 for the KYOVA Interstate Planning Commission. In April 2012, a study design was conducted as the first step of this model development effort. Based on the approach outlined in the study design document, various components of the KYOVA Travel Demand Model were developed.

The purpose of this report is to document the development process and describe the parameters and structure of the updated KYOVA Travel Demand Model that was employed as part of the KYOVA MTP update as well as document the final model calibration and validation measures.

The MPO's existing model used QRSII software and had a base year of 2000 and a forecast year of 2030. In 2010, as part of the State of West Virginia's conversion to the TransCAD modeling platform, the Caliper Corporation delivered a converted base year model in TransCAD for the KYOVA region. This converted model, to the extent practical, was a replication of the QRSII model and was the starting point for this model update.

The main objective for developing a new KYOVA travel model system was to provide information necessary for the analyses to be performed as part of the transportation planning process for the region. These analyses include those necessary for the development of such required planning documents as the Metropolitan Transportation Plan, the Transportation Improvement Program, and air quality conformity analysis as required by the federal Clean Air Act Amendments.

Model Structure

The KYOVA travel demand model follows the basic "four-step" travel demand forecasting process of trip generation, trip distribution, mode split, and trip assignment.

Trip generation is the first step in the four-step process. Trip generation determines how many trips are made by residents and employees in each zone in the region. Trips are stratified into two types: productions and attractions. Trip productions are those trips generated by a zone and are generally associated with the resident population of the zone. Trip attractions are those trips that are attracted to the zone from another zone. They are generally associated with the employment in the zone.

Trip distribution is the second step in the four-step process. Trip distribution is the process of connecting trip productions with trip attractions for each possible combination of zones (zonal interchange). The trip distribution model uses the gravity model formulation. This formulation states that the number of trips between two zones is directly proportional to the number of trip productions in the production zone and trip attractions in the attraction zone, and inversely proportional to the separation between the zones.

Mode split is typically the third step in the four-step process. In cities with extensive transit systems, the travel characteristics of the population are used to estimate the mode choice between auto and transit. Given the small portion of daily travel carried by the bus system in the KYOVA region, no separate mode choice or transit model is included.

Trip assignment is the fourth step in the traditional four-step process. Trip assignment determines which roadway path will be taken by auto travelers. Auto trips are assigned by time-of-day, using an equilibrium traffic assignment process. The equilibrium assignment process considers both free-flow travel time and the delay time due to traffic congestion. At equilibrium, no traveler is able to reduce his or her travel time on a trip by switching to an alternative route for that trip.

Model Interface

The KYOVA model has been designed to utilize TransCAD's native scripting language, Geographic Information System's Development Kit (GISDK), to provide an intuitive yet flexible interface. The model features an interface that can run different steps of the model individually or as a set. It also allows functionality in managing files, scenarios, and mapping. This setup allows for an optimal balance between efficiency and flexibility in using the KYOVA model.

The interface also allows the user to view and adjust most settings in the model, and to easily switch between scenarios that contain different sets of data, such as an alternative network, a modified external trip forecast, or a land use scenario. The interface features tools to assist the user in coding and managing future transportation projects. Finally, the interface has mapping tools that allow the user to produce maps showing data such as link level-of-service and daily volumes.
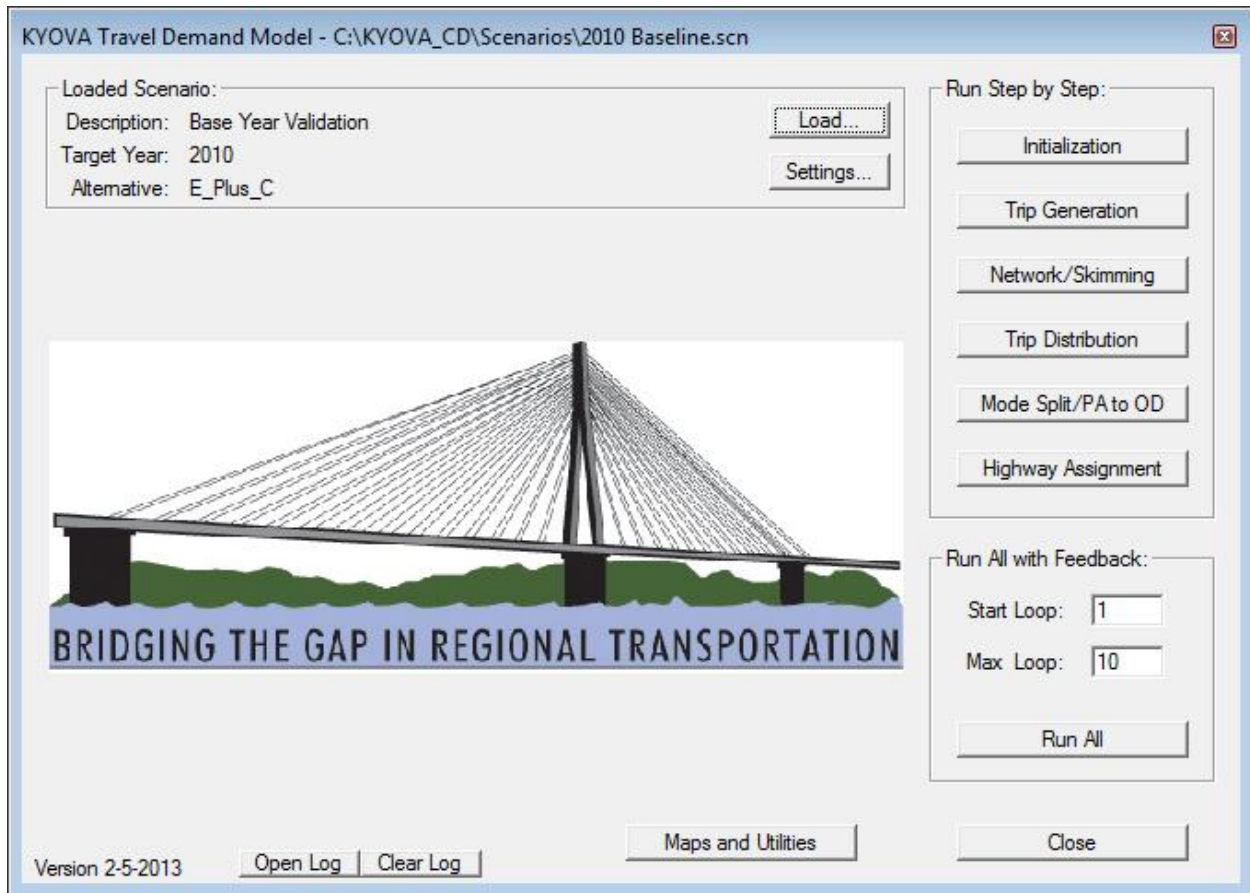
Highway Network and Traffic Analysis Zones

In order to simulate travel within the KYOVA study area, a computer network must be developed that represents the street system to be modeled. Development of the highway network involved identifying the network roads to be included and either checking or populating network data in TransCAD.

The KYOVA model boundary includes Cabell and Wayne counties in West Virginia, and Lawrence county in Ohio. The previous model included Boyd and Greenup counties in Kentucky, but these were not included with this update since they are both included in the Ashland Travel Demand Model.

The model study area and network can be seen in **Figure 1** at the end of this document.

Highway Network Database

A single master network will be used for the base year and all future year models. In TransCAD, the line layer is not the actual model network used by the travel demand modeling system. Rather, the model network is built from the line layer. This means the model network is developed as a selection set from the line layer. Having a selection set means that highway, transit, and walk networks can use a different subset of the entire street network system.

The highway network contains attributes for each line in the line layer and includes all attributes needed to perform a traffic assignment. Links that were developed for future year roads were drawn in the network as new links. Future year attributes were input in a project file and the highway network and project file were connected by giving each project a unique ID. The project file identifies attributes for the new facilities and indicates the years and scenarios in which the road is expected to be built. Widened roads include attributes along with improvement data in the future year scenarios that apply. This methodology allows a single database plus the project file to handle all potential roads in the network in a compact format. Table 1 below shows the attributes that are included in the KYOVA highway network database. See Table 26 for Project File attributes.

Table 1 – Highway Network Database Attributes					
ID	**Field Name**	**Type**	**Purpose**	**Option**	**Description**
1	ID	Integer	Read-only	Link ID	
2	Length	Real	Read-only	Length (miles)	
3	Dir	Integer	Input	Link travel direction code	
				1	One Way - A to B
				0	Two way
				-1	One Way - B to A
4	Number	String	Reference	Highway Number	
5	NAME	String	Reference	Street Name	
6	LINKTYPE	String	Old	Old Linktype	
7	FED_FC	Integer	Reference	Federal Functional Classification	
8	CNTY_FIPS	Integer	Reference	County FIPS Number	
9	COUNTY	String	Reference	County	
10	Alpha_old	Real	Old	Old Alpha value	
11	Beta_old	Real	Old	Old Beta value	

ID	Field Name	Type	Purpose	Option	Description
12	Y10_In_Network	Integer	Input		In Year 2010 highway network or not
				1	In highway network
				not 1	Not in highway network
13	Y10_Fac_Type	Integer	Input		Year 2010 Roadway Facility Type
				10	Freeway
				20	Principal Arterial
				21	Principal Arterial w/TWLTL
				30	Minor Arterial
				31	Minor Arterial w/TWLTL
				40	Collector
				41	Collector w/TWLTL
				50	Local
				51	Local w/TWLTL
				60	Centroid Connector
				70	One Way
				80	Ramp
14	Y10_Posted_Speed	Integer	Input		Year 2010 Posted speed (mph)
15	Y10_[AB/BA]_Lanes	Integer	Input		2010 Number of lanes for AB or BA direction
16	Y10_Count _[Auto/SU/CU/AllVeh] _[AM/MD/PM/OP/Daily]	Integer	Input		(Year 2010) Traffic counts by three vehicle class [Auto/SU/CU] by four time-of-day periods [AM/MD/PM/OP] and total
17	Screen_Line_IDs	Integer	Input		Screen line / Cut line definition (One single digit represents the ID of a screen line or cut line)
18	PRJ_ID[1/2/3/4/5/6]	Integer	Input		Future year project ID [1/2/3/4/5/6]
19	Area_Type	Integer	Output		Area type (by 4 category)
				1	CBD
				2	Urban
				3	Suburban
				4	Rural
20	In_Network	Integer	Scenario		In (Scenario year) highway network or not
21	Fac_Type	Integer	Scenario		(Scenario year) Roadway Facility Type
22	Posted_Speed	Integer	Scenario		(Scenario year) Posted speed (mph)
23	[AB/BA]_Lanes	Integer	Scenario		(Scenario year) Number of lanes for AB or BA direction
24	Alpha	Real	Output		Alpha parameter for BPR function
25	Beta	Real	Output		Beta parameter for BPR function
26	[AB/BA]_Preload	Real	Output		Preload traffic for AB or BA direction
27	FF_Speed	Real	Output		Free flow speed (mph)
28	FF_TT	Real	Output		Free flow travel time (minutes)
29	[AB/BA]_Cong_Speed _[AM/MD/PM/OP]	Real	Output		Congested speed (mph) by travel direction and time-of-day

ID	Field Name	Type	Purpose	Option		Description
30	[AB/BA]_Cong_TT _[AM/MD/PM/OP]	Real	Output			Congested travel time (minutes) by travel direction and time-of-day
31	[AB/BA]_MSA_Speed _[AM/MD/PM/OP]	Real	Output			MSA speed for feedback loop (mph) by travel direction and time-of-day
32	[AB/BA]_MSA_TT _[AM/MD/PM/OP]	Real	Output			MSA travel time for feedback loop (minutes) by travel direction and time-of-day
33	[AB/BA/BothDir]_Capa _[AM/MD/PM/OP/Daily]	Real	Output			Link capacity by travel direction and time-of-day
34	[AB/BA/BothDir]_VOC _[AM/MD/PM/OP/Daily]	Real	Output			Volume to capacity ratio by travel direction and time-of-day
35	[AB/BA/BothDir]_LOS _[AM/MD/PM/OP/Daily]	String	Output			Level of service by travel direction and time-of-day
				C		v/c < 0.7
				D		v/c >= 0.7 and <0.85
				E		v/c >= 0.85 and <1
				F		v/c >1
36	[AB/BA/BothDir]_Vol _[Auto/SU/CU/AllVeh] _[AM/MD/PM/OP/Daily]	Real	Output			Traffic volume by travel direction, vehicle class, and time-of-day
37	[AB/BA/BothDir]_VMT _[Auto/SU/CU/AllVeh] _[AM/MD/PM/OP/Daily]	Real	Output			Vehicle miles traveled by travel direction, vehicle class, and time-of-day
38	[AB/BA/BothDir]_VHT _[Auto/SU/CU/AllVeh] _[AM/MD/PM/OP/Daily]	Real	Output			Vehicle hours traveled by travel direction, vehicle class, and time-of-day

Traffic Analysis Zones

A traffic analysis zone (TAZ) is a geographic area that is used to divide the planning region into small, relatively homogenous similar areas in terms of land use and activity. TAZs are used to represent travel within a model study area because it is not practical or feasible to model individual households and employment. Housing and employment data is aggregated to the TAZ, and the TAZs are used through the model process to calculate the origin and destination of trips in the model.

KYOVA updated its TAZ structure slightly in 2011 based on the new 2010 Census TAZ boundaries, Census block and block group boundaries, and other geographical barriers.

The KYOVA TAZs are stored as an area layer in the TransCAD environment. Based on the TAZ ID number, a database is then associated with each TAZ. This database contains all of the demographic and employment data needed for trip generation.

Creating unique sets of TAZ IDs for specific TAZ types can often speed external processing of trip table information and make data analysis and processing easier. In TransCAD, TAZ and network nodes are all part of a point layer. It is helpful to use ID numbers to differentiate between a point as a TAZ centroid and one that is a network node. The KYOVA TAZ/point layer numbering scheme puts internal TAZs at the beginning of the numbering sequence, followed by external TAZs and then network nodes. Internal TAZ numbers begin with ID 1; external TAZ numbers begin with ID 9001; and network node numbers start at 10001. Gaps in the

numbering system are not an issue for TransCAD because the ID (which must be unique) is interpreted by TransCAD as a label, not a number.

Table 2 – TAZ Numbering Summary		
Summary	TAZ Range	TAZs
Internal TAZs	1 - 9000	299
External TAZs	9001 - 9020	20
Total		319

The KYOVA TAZ structure can be seen in **Figure 2** at the end of this document.

External Zone Structure

There are 20 external stations in the 2010 KYOVA model compared to 27 external stations in the previous KYOVA model. External stations changed due to the deletion of Boyd and Greenup counties in Kentucky from this model update.

Locations of the 2010 model external stations can be seen in **Figure 3** at the end of this document.

Zonal Data

Zonal data for the KYOVA model was obtained from several sources, including the U.S. Census, and InfoUSA (a commercial provider of employment data). 2010 Census data was used to develop the 2010 household totals by TAZ. Information from the 2010 Census and the American Community Survey (ACS) helped in developing household totals by household size and number of workers.

2010 employment data was obtained by location by KYOVA through their contract with Reference USA (InfoUSA). The data was cross checked with employment data from Workforce WV to improve accuracy. Employment data were then grouped into five main categories:

- Industrial (SIC Groups 1-49) – Includes employment such as manufacturing, agriculture, construction, and freight services.

- Retail (SIC Groups 50-59, excluding 55 and 58) – Includes wholesale trade and retail trade.

- Highway Retail (SIC Groups 55 and 58) – Includes retail that falls into the category of fast food restaurants, service stations, and other types of eating and drinking establishments.

- Office (SIC Groups 60-69, 90-98) – This category includes finance, insurance, real estate, and governmental type offices.

- Service (SIC Groups 70-89, 99) – Employment data falling into this category are generally classified as hotels, personal and business services, auto repair, and other service type establishments.

Table 3 – TAZ Attributes					
ID	Field Name	Type	Purpose	Options	Description
1	ID	Integer	Read-only	TAZ ID	
				< 9000	Internal TAZ centroids
				9001-9020	External stations
2	Area	Real	Read-only	Area size (square miles)	
3	County	String	Input	County name (see above)	
4	Zone_Type	String	Reference	Internal or External	
5	Area_Type	Integer	Input	Area type (by 4 category)	
				1	CBD
				2	Urban
				3	Suburban
				4	Rural
6	Terminal_Time_P	Integer	Input	Terminal time of the zone (minutes) for productions	
7	Terminal_Time_A	Real	Input	Terminal time of the zone (minutes) for attractions	
8	[HH1/HH2/HH3/HH4]_[VH0/VH1/VH2/VH3]	Integer	Scenario	(scenario year) Number of households by household size and vehicle ownership	
9	[WK0/WK1/WK2/WK3]_HH	Integer	Scenario	(scenario year) Number of households by number of worker in household	
10	Students	Integer	Scenario	(scenario year) Total number of school age children	
11	Total_HH	Integer	Scenario	(scenario year) Total number of households	
12	Total_Population	Integer	Scenario	(scenario year) Total population	
13	HwyRet	Integer	Scenario	(scenario year) Employment in Highway Retail category	
14	Ind	Integer	Scenario	(scenario year) Employment in Industry category	
15	Retail	Integer	Scenario	(scenario year) Employment in Retail category	
16	Office	Integer	Scenario	(scenario year) Employment in Office category	
17	Service	Integer	Scenario	(scenario year) Employment in Service category	
18	Total_Emp	Integer	Scenario	(scenario year) Total employment	
19	School_Enrollment	Integer	Scenario	(scenario year) K-12/College school Enrollment	
20	ADT	Real	Scenario	(scenario year) ADT at external station	
21	Pct_[Auto/SU/CU]	Real	Scenario	(scenario year) percent by vehicle class at external station	
22	Pct_IE_[Auto/SU/CU]	Real	Scenario	(scenario year) In-bound factor by vehicle class at external station	
23	Pct_[AM/MD/PM/OP]	Real	Scenario	(scenario year) Time of day split at external station	
24	HBW_P_[AM/MD/PM/OP]	Real	Output	HBW productions by time-of-day	
25	HBW_A_[AM/MD/PM/OP]	Real	Output	HBW attractions by time-of-day	

ID	Field Name	Type	Purpose	Options	Description
26	HBS_P_[AM/MD/PM /OP]	Real	Output		HBS productions by time-of-day
27	HBS_A_[AM/MD/ PM/OP]	Real	Output		HBS attractions by time-of-day
28	HBO_P_[AM/MD/ PM/OP]	Real	Output		HBO productions by time-of-day
29	HBO_A_[AM/MD/ PM/OP]	Real	Output		HBO attractions by time-of-day
30	NHB_P_[AM/MD/ PM/OP]	Real	Output		NHB productions by time-of-day
31	NHB_A_[AM/MD/ PM/OP]	Real	Output		NHB attractions by time-of-day
32	IE_Auto_P_[AM/MD /PM/OP]	Real	Output		Balanced IE Auto productions by time-of-day
33	IE_Auto_A_[AM/MD /PM/OP]	Real	Output		Balanced IE Auto attractions by time-of-day
34	LT_TRK_P_[AM/MD /PM/OP]	Real	Output		SU truck productions by time-of-day
35	LT_TRK_A_[AM/MD /PM/OP]	Real	Output		Balanced SU truck attractions by time-of-day
36	SU_TRK_P_[AM/MD /PM/OP]	Real	Output		SU truck productions by time-of-day
37	SU_TRK_A_[AM/MD /PM/OP]	Real	Output		Balanced SU truck attractions by time-of-day
38	CU_TRK_P_[AM/ MD/PM/OP]	Real	Output		CU truck productions by time-of-day
39	CU_TRK_A_[AM/ MD/PM/OP]	Real	Output		Balanced CU truck attractions by time-of-day
40	Pop_Density	Real	Output		Population density of the zone (person per square mile)
41	Emp_Density	Real	Output		Employment density of the zone (employment per square mile)

Trip Generation

Since household travel behavior surveys were not conducted as part of the development of the KYOVA regional travel demand model, trip generation rates were "borrowed" from suitable urban areas that had recently conducted such surveys as a part of their model development.

As a precursor to this, KHA had NuStats mine data from recent travel surveys they conducted to test the transferability of trip rate inputs from other areas to the KYOVA modeling area. First, NuStats identified study areas from an existing database of household travel surveys that closely mirrored the population size and socio-demographic mix of residents in the Huntington, WV area. Once these were identified, NuStats selected the appropriate household travel survey databases for this effort. Finally, NuStats prepared and analyzed the data for computation of single- and cross-classification trip generation rates with the purpose of informing the trip generation model for KYOVA.

Trip rates were computed on data from five selected survey data files from the following locations:

- Rogue Valley, Oregon
- Chattanooga, Tennessee
- Knoxville, Tennessee
- Ohio "Cluster" #1 (Hancock, Hardin, Logan, and Champaign Counties)
- Ohio "Cluster" #2 (Adams, Brown, Highland, Scioto, Fayette, Pike, Ross and Vinton Counties)

Table 4 – 2006-2008 ACS Distribution by Selected Geography (From NuStats report)						
	KYOVA	**Rogue Valley**	**Chattanooga**	**Knoxville**	**Ohio Cluster #1**	**Ohio Cluster #2**
Total Households	**83,544**	**69,533**	**169,257**	**352,536**	**77,383**	**127,270**
White	94.4%	91.6%	81.4%	91.0%	95.4%	94.7%
African American	3.1%	0.6%	14.9%	5.5%	1.3%	2.4%
Other	1.7%	7.8%	3.7%	3.4%	3.3%	2.9%
HH Size 1	29.7%	28.3%	27.9%	28.8%	27.1%	25.8%
HH Size 2	36.6%	36.6%	36.4%	36.3%	36.5%	35.0%
HH Size 3	16.4%	14.9%	15.6%	16.7%	14.5%	17.3%
HH Size 4+	17.3%	20.2%	20.2%	18.2%	22.0%	21.9%
HH Income <$25,000	35.8%	31.0%	26.7%	28.2%	25.4%	33.5%
$25,000 to $50,000	28.5%	29.3%	27.8%	27.2%	27.2%	28.9%
$50,000 to $75,000	17.2%	15.9%	18.7%	19.0%	22.1%	18.8%
$75,000 or more	18.5%	23.7%	26.8%	25.7%	25.3%	18.7%
Age <25 yrs	31.6%	30.6%	36.4%	32.6%	34.9%	32.5%
65+ yrs	15.7%	15.0%	14.0%	14.4%	13.5%	13.9%
65 Years and Over	0.9%	7.3%	2.5%	2.2%	1.6%	0.8%

This data was combined with trip rate information from other sources (old KYOVA model, 2000 RIC model, Ashland model, Goldsboro NC model, Greenville NC model) and engineering judgment was used to determine the best rates for use in the KYOVA model. The NuStats *Trip Rate Transferability Analysis Final Report* is available under separate cover.

Internal Trip Productions

The trip generation models used in the KYOVA regional travel demand model explicitly recognizes the connection between household composition and trip-making characteristics. The model estimates person-trip generation for four purposes, based on household characteristics that are relatively easy to obtain, derive, and forecast. These trip purposes are:

Home-based work (HBW)

Home-based school (HBS)

Home-based other (HBO)

Non-home-based (NHB)

The methodology employed recognizes the strong relationships between travel behavior and household "type", reflecting the degree to which household composition influence travel characteristics.

Table 5 – Trip Production Variable by Purpose				
Independent Variable	**HBW**	**HBS**	**HBO**	**NHB**
Workers/Household	X			
HH Size by Vehicles			X	X
Students		X		

Home-Based Work (HBW)

Workers/household is a strong predictor of home-based work trips. Many other variables (income, vehicles, and persons) share co-linearity's with workers/household, but are weaker predictors. Because of their interactions, combining these variables with workers/household does not substantially improve the explanatory power of the model.

As shown in **Table 6** on the next page, the increase in HBW trip rates associated with the number of workers per household is not linear. This is assumed because of an increasing proportion of part-time jobs in multi-worker households, which increase the likelihood that one household worker will not make a work trip every workday.

HBW trip rates were borrowed from Ohio Cluster #2 in the NuStats data and adjusted (up or down) based on observed VMT in the area for each county. Adjustments were made by county to account for differences in travel characteristics between the different counties that became apparent when comparing model VMT versus actual VMT.

Table 6 – Household Trip Rates for HBW Trips	
Workers/HH	**HBW Trips/HH**
Lawrence County	
0	0.00
1	1.717
2	2.533
3+	3.544
Cabell County	
0	0.00
1	2.222
2	3.278
3+	4.587
Wayne County	
0	0.00
1	1.010
2	1.490
3+	2.085

Home-Based School (HBS)

Due to the availability of data on the number of students per household, the Home-based school trip model is a simple calculation of number of students times a trip rate. For this model, the number of students was determined to be the most predictive of Home-based school trips.

HBS trip rates were borrowed from the 2000 RIC travel demand model and adjusted based on observed VMT in the area for each county. Adjustments were made by county to account for differences in travel characteristics between the different counties that became apparent when comparing model VMT versus actual VMT.

Table 7 – Household Trip Rates for HBS Trips	
Students	**HBS Trips/Student**
Lawrence County	
1	1.244
Cabell County	
1	1.610
Wayne County	

1	0.732

Home-Based Other (HBO)

This trip category combines all home-based trips not covered by HBW and HBS (such as shopping and recreation for example). As such, there is no single, clear-cut variable that determines HBO trip rates. For this model, the combination of household size and available vehicles was determined to be the most predictive of Home-based other trips.

HBO trip rates were borrowed from the Ashland travel demand model and adjusted based on observed VMT in the area for each county. Adjustments were made by county to account for differences in travel characteristics between the different counties that became apparent when comparing model VMT versus actual VMT.

Table 8 – Household Trip Rates for HBO Trips			
Household Size	**0 Veh Available**	**1 Veh Available**	**2+ Veh Available**
Lawrence County			
1	1.193	1.836	1.836
2	2.203	3.075	3.075
3	3.522	4.379	4.379
4+	4.536	5.670	6.557
Cabell County			
1	1.544	2.376	2.376
2	2.851	3.980	3.980
3	4.558	5.667	5.667
4+	5.870	7.337	8.485
Wayne County			
1	0.702	1.080	1.080
2	1.296	1.809	1.809
3	2.072	2.576	2.576
4+	2.668	3.335	3.857

Non-Home Based (NHB)

These trips differ fundamentally from the other purposes, since they occur away from the home, and are not associated geographically with the household location. The production end of the NHB trips merely provides an estimate of the NHB trips associated with each household, and, in aggregate, a control total for the entire study area. Typically the attraction ends of HB trips determine the locations of these non-directional trips.

For this model, it was decided to use household size by vehicles available to determine NHB trips. NHB trip rates were borrowed from the 2000 RIC travel demand model and the Ashland travel demand model and adjusted based on observed VMT in the area for each county. Adjustments were made by county to account for differences in travel characteristics between the different counties that became apparent when comparing model VMT versus actual VMT.

Table 9 – Household Trip Rates for NHB Trips			
Household Size	0 Veh Available	1 Veh Available	2+ Veh Available
Lawrence County			
1	0.575	0.986	0.986
2	0.979	1.420	1.420
3	1.573	1.921	1.921
4+	1.799	2.848	2.848
Cabell County			
1	0.744	1.276	1.276
2	1.267	1.837	1.837
3	2.035	2.486	2.486
4+	2.328	3.685	3.685
Wayne County			
1	0.338	0.580	0.580
2	0.580	0.835	0.835
3	0.925	1.130	1.130
4+	1.130	1.675	1.675

Internal Trip Attractions

Corresponding trip attraction models were developed for each of the four trip production purposes. For all home-based trips, the attraction end of the trip is defined as the non-home end. In the case of non-home based trips, the trip attraction model provides both origin and destination information, since, by definition, these trips do not originate from the home.

Regression equations are widely used for estimating trip attractions in travel demand models. The general form of the regression equation uses several known independent variables to predict the dependent variable – trip attractions – for each trip purpose.

Similar to trip productions, trip attraction rates were borrowed from a number of different sources including the old KYOVA model, as well as the 2000 RIC travel demand model and the Ashland travel demand model. Engineering judgment was used to determine the specific rates by purpose and type.

Table 10 – Person Trip Attraction Factors							
Purpose	Households	Industrial	Retail	High-Retail	Office	Service	School Enrollment
HBW	1.45	--	--	--	--	--	--
HBS	--	--	--	--	--	--	1.5
HBO	1.48	.44	2.976	10.58	.44	1.7	--
NHB	.268	.285	4.7	4.7	.285	.889	--

External Trips

The number of base year vehicle trips at each external station was set equal to the average daily traffic (ADT) traffic count at the station. Using the observed vehicle classification, time-of-day, and other information, the ADTs at external stations are further divided by the following components:

- Auto, SU, CU

- EE Auto, EI Auto, EE SU, EI SU, EE CU, EI CU

Three vehicle classes are modeled and assigned to the highway network in the KYOVA model: Auto, Single-Unit Truck (SU), and Combination-Unit Truck (CU). ADTs at all external stations are split into these three vehicle classes first based on existing model information.

Percent splits between EE and EI trips at each external station were also based on existing model information except in cases where the location of the external station changed. At these locations, information from the Ashland model as well as engineering judgment was used to estimate appropriate values.

Time-of-day trip factors for external stations were developed by taking an average of the internal trip purposes (HBW, HBO, NHB) for each time of day. HBS trips were not included because of the small amount coming into the area from external locations.

Table 11 –External Station ADT and Vehicle Classification Splits							
Station	Location	County	2010 AADT	% Auto	% SU Truck	% CU Truck	% Through
9001	US 52 N	Lawrence	9120	90%	6.0%	4.0%	40%
9002	OH 522	Lawrence	660	97%	2.0%	1.0%	0.0%
9003	OH 93 N	Lawrence	1800	92%	5.0%	3.0%	0.0%
9004	OH 141	Lawrence	730	95%	3.0%	2.0%	0.0%
9005	OH 7 E	Lawrence	3120	95%	3.0%	2.0%	5.5%
9006	WV 2 E	Cabell	6000	95%	3.0%	2.0%	0.5%
9007	Mason Rd	Cabell	1640	97%	2.0%	1.0%	0.0%
9008	I-64 E	Cabell	32500	85%	9.0%	6.0%	8.6%
9009	US 60 E	Cabell	9000	90%	6.0%	4.0%	0.0%
9010	Bulls Gap	Cabell	700	97%	2.0%	1.0%	0.0%

9011	WV 10	Cabell	3500	95%	3.0%	2.0%	0.4%
9012	CR 21	Wayne	300	97%	2.0%	1.0%	0.0%
9013	WV 37 E	Wayne	800	96%	2.0%	2.0%	0.0%
9014	12-Pole Creek Rd	Wayne	300	97%	2.0%	1.0%	0.0%
9015	US 52 S	Wayne	6600	95%	3.0%	2.0%	0.0%
9016	WV 37 W	Wayne	9300	95%	3.0%	2.0%	0.0%
9017	I-64 W	Wayne	27500	85%	9.0%	6.0%	8.3%
9018	US 60 W @ CL	Wayne	9400	95%	3.0%	2.0%	2.0%
9019	US 60 W @ River	Lawrence	34000	94%	4.0%	2.0%	10.3%
9020	OH 93 S @ River	Lawrence	10500	95%	3.0%	2.0%	3.0%

Through trips were directly modeled as in-bound and out-bound trips. The total number of in-bound and out-bound trips was balanced by holding the in-bound total number of trips constant. External-Internal truck trips include SU and CU trucks. For each classification, total trips produced at each external station are a function of ADT, percent by class, percent by time-of-day and percent EI. Based on the Quick Response Freight Manual (QRFM), the EI trip production was added to the internal truck trips and balanced together with the internal truck trip attractions by holding the production end constant. Similar to EI trucks, EI auto trips are a function of ADT, percent auto, percent time-of-day and percent EI. EI auto attractions were derived at the TAZ level based on various employment categories and total number of households. Linear regression models based on employment and number of households in each internal zone was developed for EI auto trip attractions. The linear regression coefficients were borrowed from surveys in North Carolina. EI auto trip attraction rates are summarized in **Table 12**.

Table 12 – EI Auto Trip Attraction Model Coefficients	
Variable	**Coefficient**
Employment (High-Retail)	3.74
Employment (Industry)	0.40
Employment (Retail)	3.74
Employment (Office)	0.45
Employment (Service)	0.45
Households (Total)	0.25
School Enrollment	0.25

External trip productions were held constant at the external station locations since there is a higher level of certainty with the volumes at these locations than the attractions being derived at the TAZ level.

External trips are distributed using the gravity model, the same as internal trips.

Truck Trip Model

In the KYOVA model, internal truck travel was estimated for three vehicle classification types: four-tire commercial vehicles (Light Truck), single unit trucks with six or more times (SU), and combination trucks (CU). Total truck trips using the highway network can be divided into three types: External-External (EE), External-Internal (EI), and Internal trips.

Internal truck trip generation is based on the linear regression models by various employment categories and number of households as defined in the QRFM procedures. The default commercial vehicle trip rates in the QRFM manual were used as the starting points. It is recognized that the QRFM rates are based on Phoenix, Arizona's survey, and truck trip rates may vary considerably from region to region. Since a truck land use trip generation survey for the KYOVA region does not exist, common practice suggests that the QRFM rates should be coded and then adjusted during the calibration effort. Based on this, the trip generation rates shown in **Table 13** were developed as QRFM tailored rates specific to the KYOVA model application.

Table 13 – Commercial Vehicle Trip Generation Rates			
Variable	**Light Truck**	**SU Truck**	**CU Truck**
Employment (High-Retail)	0.888	0.164	0.065
Employment (Industry)	0.938	0.157	0.104
Employment (Retail)	0.888	0.164	0.065
Employment (Office)	0.437	0.022	0.009
Employment (Service)	0.467	0.305	0.075
Households (Total)	0.251	0.050	0.038

Production and attractions for internal truck trips are 50/50 splits after the total demand is estimated. The SU and CU truck productions and attractions from the EI and internal truck trip generation step are added together, and distributed using the gravity model. The productions and attractions for SU and CU trucks were balanced by holding the production end constant.

Due to a lack of significant time-of-day classification count coverage, the time-of-day split factors for internal truck trips were borrowed from the Memphis, TN model. These splits can be seen in the table below.

Table 14 – Truck Time of Day Factors				
Purpose	**AM**	**MD**	**PM**	**OP**
LT_TRK	17.10	27.20	29.20	26.50
SU_TRK	17.90	31.40	27.80	22.90
CU_TRK	16.20	27.50	26.90	29.40

Trip Distribution

Trip distribution, the second step in the traditional four-step modeling process, matches person trip-ends (trip productions and trip attractions) estimated in the trip generation process to produce production-attraction person trip tables by purpose. To complete this process, a trip distribution has to be used that attempts to account for differences in attractiveness and accessibility of each possible zone-zone interchange in the model, reflecting each zone's land use and roadway network characteristics. The KYOVA model uses the most common type of trip distribution model, the gravity model.

Gravity Model

The trip distribution step in the traditional four-step modeling process matches the person trip end (trip productions at the households and trip attractions at employment sites) estimated in trip generation to produce production-attraction person trip tables by purpose. The underlying assumption is that the trip productions and attractions are distributed in a manner that accounts for differences in accessibility and attractiveness of each zone pair reflecting the land use and transportation system characteristics.

The gravity model for trip distribution is defined as follows:

$$T_{ij} = P_i \left(\frac{A_j F_{ij} K_{ij}}{\sum_{k=1}^{zones} A_k F_{ik} K_{ik}} \right)$$

where:

T_{ij} is the number of trips from zone i to zone j
P_i is the number of trip productions in zone i
A_j is the number of trip attractions in zone j
F_{ij} is the "friction factor" relating the spatial separation between zone i and zone j
K_{ij} is an optional trip distribution adjustment factor for interchanges between zone i and zone j

The friction factors are inversely related to spatial separation of the zones—as the travel time increases, the friction factor decreases. A number of different functional forms have been used for friction factors. In fact, early gravity models used "hand fitted" friction factors. More recently, however, it has been discovered that the "gamma" function does a very good job for trip distribution. Using such a function produces a smooth, continuous curve. The gamma function can be stated as follows:

$$F_{ij} = a * t_{ij}^b * e^{c*t_{ij}}$$

where:

F_{ij} is the friction factor
a, b, and c are model coefficients
t_{ij} is the travel time
e is the base of the natural logarithms

Table 15 – Gamma Function Settings			
Purpose	a	b	c
HBW	38375	0.140	0.120

HBS	50000	0.550	0.100
HBO	80000	1.700	0.060
NHB	40000	0.450	0.095
IE_AUTO	500000	2.500	0.600
LT_TRK	418908	1.300	0.080
SU_TRK	418908	1.300	0.050
CU_TRK	200000	1.000	0.060

Travel Impedances

One of the major inputs to gravity model-based trip distribution models is the travel impedance matrix. For the KYOVA trip distribution model, travel impedances are based on highway travel times. The highway travel times are based on shortest travel paths for each possible zonal interchange and are augmented with intrazonal times and terminal times prior to distribution.

Free flow speeds are the speeds at which a vehicle can traverse the roadways without interference from other vehicles. The only delay that is experienced by vehicles at free-flow is the delay caused by intersection controls – signal lights, stop signs, and yield signs. The uncongested speeds used in the KYOVA model are average speeds based on free-flow conditions which do not explicitly treat the delay at intersections. Free-flow speeds are calculated from the model posted speeds multiplied by a speed factor (found in the speed_factor.bin file). This was done for two reasons: (1) average speeds are realistic since vehicles tend to travel above the speed limit except for delay at intersections, and (2) for a regional network, it is more important to have consistent speeds than to have additional detail.

Once link-specific uncongested travel times have been estimated, shortest travel time paths can be built, and zone-to-zone travel times can be saved in matrices.

Estimated congested travel times are based on the expected travel speeds that would be encountered in a peak period. Since trip distribution is performed prior to traffic assignment, the congested times must be developed through an iterative process.

- Link specific free-flow travel times are calculated

- Shortest path interzonal travel time matrices (skims) are determined using the traffic assignment model in TransCAD for free-flow travel times; skims are augmented with terminal times and intrazonal times

- Trip distribution is performed for all trip purposes based on the free-flow skims

- Vehicle trip tables are developed and peak period assignments are performed, and congested times are saved to a matrix

- Trip distribution is performed again based on congested skims

The model is also set up to have free flow speed adjustment factors which can vary by area type as well as congested speed adjustment factors which can vary by time of day and area type (found in speed_factor.bin file). While free flow speed adjustment factors aid in model calibration, congested speed adjustment factors give the model a good start for the first iteration. If we use free flow skims for the first iteration as impedance, the model

will converge slowly. By providing congested speed estimates for the first iteration before assignment, we help the model start with congested skims that are similar to reality or the assignment results.

Terminal/Intrazonal Travel Times

The highway network is represented by roads classified as collectors, arterials and freeways with some local roads added for network connectivity. Household surveys, however, query people on their overall trip travel time. This travel time considers the access and egress time at either end of the trip. Since the model will not simulate each individual household or business, the time needed to access a vehicle and travel to a road which is actually in the model must be considered. At the destination end, people must find parking and walk to their final destination. Consequently, some way must account for travel time not occurring on the simulated model network. This accounting mechanism is referred to as terminal time.

Terminal time can vary by setting. Typically, in a CBD setting, it takes longer to find a parking space and walk to the final destination than in a rural or even an urban setting where the parking is closer to the doorstep. *NCHRP Report 365: Travel Estimation Techniques for Urban Planning* provides some general guidelines for these terminal times. These terminal times were compared against actual field tests, and terminal times of one minute were chosen for rural, suburban and urban area types, and terminal times of two minutes were chosen for CBD area types.

Trips that stay within a TAZ are referred to as intrazonal trips. Intrazonal trips are not assigned to the model network. To properly account for these trips in the distribution process, an intrazonal travel time must be computed. For the KYOVA model, intrazonal travel times are calculated by taking one half of an average travel time to three neighboring zones, along with the terminal time. This process accounts for variable zone sizes (larger zones at the model periphery and smaller zones in the core).

Average Trip Length Targets

Since no travel surveys have been conducted for the KYOVA area, data from previous information will be utilized to establish whether the 2010 model average trip lengths are adequate for model calibration.

Table 16 shows the comparison of travel times from available data.

Table 16 – Average Trip Lengths (min)						
Purpose	O-D Survey 60's	1972 Model	1990 Model	Ashland 2002	2002 Survey	2010 Model
HBW	13.2	13.1	20.75	20.976	16.5	17.2
HBS	8.5	7.2	15.90	--	19.5	17.3
HBO	10.6	10.6	18.71	19.465	15.4	15.3
NHB	10.1	10.1	15.66	20.364	13.3	13.1
IE_Auto	19.9	--	--	--	--	32.0
LT_Trk	9.5	9.7	--	--	13.3	11.4
SU_Trk	--	--	--	--	--	17.3
CU_Trk	--	--	--	--	--	20.3

Mode Split/Time of Day

In the mode split step, the total person trips that are output from the trip generation and trip distribution steps are split into trips by mode. In many models, particularly those in large urban areas with significant transit systems, a mode choice model is used to identify which trips use automobile, transit, walk, or other forms of travel. In such a model, the characteristics of travelers and modes are used to calculate the probabilities of using each mode.

The development of a true mode choice model for the KYOVA region is not planned at this time. Due to the high level of investment required to create a sound mode choice model and the relatively low number of non-auto users, the mode split step for the KYOVA model has been developed as a factoring process. The mode split procedure has been designed in TransCAD in a modular format to allow for additional capabilities, such as a true mode choice model, if in the future such a submodel is deemed as required for the region. In the current process, the person trips by purpose will be factored to eliminate the non-motorized, transit and auto passenger trips, leaving only the auto driver (vehicle) trips.

These factors were derived from the 1998 Greenville, NC and 2003 Goldsboro, NC household travel surveys, and are based on trip purpose and distance. Through analysis of the survey data, it was found that the most reliable way to reduce the trip tables to automobiles only was based on distance. Shorter trips were much more likely to be classified as walk, bike, or transit/school bus, while longer trips were made almost exclusively by automobile. **Table 17** shows the mode split factors for the KYOVA model. The mode split factors can be read as a percentage. The HBW factor of .70 for trips between 0-1 miles means 70% of these trips are automobile trips. These factors are required only for the non-commercial internal trip purposes, since the external-internal and commercial trip purposes are treated as vehicle trips through the entire model.

Table 17 – Mode Split Factors				
Distance	**HBW**	**HBS**	**HBO**	**NHB**
0-1 Miles	0.70	0.57	0.78	0.85
1-2.5 Miles	0.98	0.87	0.975	0.98
2.5-7.5 Miles	0.98	0.90	1.00	0.985
7.5+ Miles	1.00	0.95	1.00	0.985

The mode split procedure is also the point where the internal trip purposes are taken from person trips to vehicle trips using vehicle occupancy factors. Vehicle occupancy factors for the KYOVA model were derived from the old KYOVA model. **Table 18** shows the occupancy factors used in the KYOVA model, along with occupancy rates from other sources as a point of comparison.

Table 18 – Vehicle Occupancy Factors					
Purpose	**1990 HIATS**	**2004 Clarksville, TN**	**2000 Ashland, KY**	**Old KYOVA Model**	**KYOVA Model**
HBW	1.27	1.08	1.11	1.54	1.35
HBS	4.56	3.58	--	2.29	2.00

HBO	1.64	1.20	1.58	1.55	1.54
NHB	1.35	1.15	1.66	1.73	1.70

- 1990 HIATS from HIATS Long Range Plan – Technical Analysis 1997
- 2004 Clarksville, TN from Clarksville Urbanized Area Travel Demand Model – Model Documentation and Users Guide
- 2000 Ashland and Old KYOVA Model from Final Draft Report – Updating and Validating the Travel Demand Forecasting Process – KYOVA, October 2004

Next, time-of-day/direction split factors convert the vehicle trip tables from production-attraction format to origin-destination format. At the same time, daily trips are split into four time periods; morning, midday, afternoon, and night.

In a highway assignment, peak period trip tables representing more than one hour are normally assigned while link capacities are specified in vehicles per hour. As a result, factors specifying the percentage of trips that take place within the peak hour of the time period being assigned are used to relate the hourly capacities to multiple-hour trip tables (see Capacity Factor in Table 20).

Table 19 summarizes the percent of trips by starting time for the 24 one-hour periods in a day for each internal trip purpose. This information was taken directly from the old KYOVA model.

Table 19 – Percent of Trips by Time of Day			
Time Period	**HBW**	**HBS**	**HBO**	**NHB**
00:01-01:00	0.83	0.58	1.56	0.92
01:01-02:00	0.73	0.45	0.99	0.50
02:01-03:00	0.88	0.50	0.75	0.38
03:01-04:00	0.98	0.41	0.59	0.20
04:01-05:00	1.39	0.30	0.80	0.16
05:01-06:00	4.67	0.74	0.92	0.28
06:01-07:00	11.58	2.56	1.21	0.24
07:01-08:00	15.80	9.89	1.30	0.40
08:01-09:00	7.80	7.29	4.19	1.02
09:01-10:00	2.70	3.41	5.63	4.16
10:01-11:00	1.69	3.38	6.41	6.16
11:01-12:00	3.81	6.40	6.05	11.70
12:01-13:00	3.72	6.55	6.50	12.02
13:01-14:00	4.23	4.86	6.67	11.90
14:01-15:00	2.95	5.56	7.65	10.14
15:01-16:00	5.82	11.18	7.86	9.12
16:01-17:00	9.52	10.53	7.21	10.12

17:01-18:00	8.11	9.68	6.75	7.38
18:01-19:00	3.51	4.74	7.01	3.46
19:01-20:00	1.66	2.56	5.99	1.72
20:01-21:00	1.53	2.80	4.77	3.00
21:01-22:00	1.74	2.52	4.01	2.68
22:01-23:00	2.36	1.56	3.04	1.10
23:01-24:00	1.96	1.58	2.16	1.26

For the KYOVA model, peak periods were determined to be as follows:

- Morning (AM) peak from 06:01-09:00
- Midday (MD) peak from 09:01-16:00
- Afternoon (PM) peak from 16:01-19:00
- Night (OP) peak from 19:01-06:00

Peak period percentage splits and peak period capacity factors can be seen in **Table 20** below.

Table 20 – Time of Day/Capacity Factors				
Purpose	**AM**	**MD**	**PM**	**OP**
HBW	35.18	24.92	21.14	18.73
HBS	48.49	3.21	45.83	2.47
HBO	6.70	46.77	20.97	25.58
NHB	1.66	65.20	20.96	12.20
Capacity Factor	1.60	3.10	1.60	2.70

Traffic Assignment

Traffic assignment models are used to estimate the flow of traffic on a network. These models take as input a matrix of flows that indicate the volume of traffic between origin and destination (O-D) pairs. The flows for each O-D pair are loaded onto the network based on the travel time or impedance of the alternative paths that could carry this traffic.

Historically, a wide variety of traffic assignment models have been applied. The two most common have been All-or-Nothing (AON) assignment and User Equilibrium (UE) assignment. All-or-nothing assignment does not consider link capacities or congestion, and assigns based on the shortest free-flow paths. Equilibrium methods take account of the volume dependence of travel times, and result in the calculation of link flows and travel times that are mutually consistent. Equilibrium flow algorithms require iteration between assigning flows and calculating loaded travel times. Despite the additional computational burden, equilibrium methods will almost always be preferable to other assignment models. Equilibrium assignment is typically preferred to All-or-Nothing assignment due to the fact that AON assignment ignores the fact that link travel times are flow dependent (i.e., that they are a function of link volumes) when there is congestion, or that multiple paths are used to carry traffic for each specific O-D pair.

Recently, a variation of the User Equilibrium method has been incorporated into the TransCAD platform called Origin User Equilibrium (OUE).

From TransCAD Program Help (TransCAD 5.0, Build 1880)

Similar to the UE methods, it uses an iterative process to achieve a convergent solution in which no travelers can improve their travel times by shifting routes. In each iteration, TransCAD computes network link flows, which incorporate link capacity restraint effects and flow-dependent travel times.

Origin user equilibrium assignments require more memory than the traditional Frank-Wolfe (FW) algorithms and its variants that are used for computing user equilibrium in TransCAD and most other planning packages. However, OUE methods require much less memory than path-based methods. The idea behind origin-based assignment is that the equilibrium solution for each origin is an acyclic graph. Origin-based methods maintain acyclic solutions by processing origin subnetworks. This addresses a major weakness of FW, which has trouble removing cycles once they arise. Origin user equilibrium methods achieve an equilibrium for each origin, and prohibit flow from links that are part of cycles, giving greater computational efficiency. Instead of keeping track of all the paths for each O-D pair, one keeps the solution for each origin.

Origin user equilibrium algorithms can compute solutions to tiny gaps that are not achievable with traditional algorithms. This makes it possible to compare traffic assignments with more highly converged ones, and research has indicated that use of smaller gaps increases the accuracy and validity of project impact assessments.

If only a modest level of convergence is being sought such as a relative gap of 1% (0.01), OUE may be significantly slower than the traditional FW assignment in TransCAD. This is especially true if the hardware utilized has multiple cores which are fully exploited by the FW UE procedure and much less exploited by OUE. For gaps of .0001 or lower, it is our experience that OUE will almost always be faster.

The KYOVA travel demand model uses a combination of a free-flow assignment and an origin user equilibrium assignment. In this model, the external-external (EE) trips were pre-assigned to the network using a free-flow (AON) assignment. These travelers are generally less familiar with the local roadway network, so they tend to stay on major highways and do not often divert due to congestion, whereas local travelers will find alternate routes in the case of congestion on their preferred route.

Link Performance Functions

Origin User Equilibrium assignment updates travel times iteratively based on link performance functions, which are mathematical descriptions of the relationships between travel time and link volume. The Bureau of Public Roads (BPR) formulation is one of the most-commonly used link performance functions. The BPR function relates link travel times as a function of the volume/capacity ratio according to:

$$T_f = T_o * \left(1 + a * \left[\frac{V}{C} \right]^b \right)$$

where: T_f = congested link travel time
T_o = link free-flow travel time
V = link volume
C = link capacity
a, b = calibration parameters

TransCAD's Origin User Equilibrium trip assignment model uses the BPR function as its link performance function. The BPR function parameters can be set globally, by link type, or for each specific link.

For the KYOVA model, Alpha and Beta settings were set by link type. Alpha and Beta settings can be seen in **Table 21** below and are found in AB_Lookup.bin.

Table 21 – Alpha - Beta Settings		
Facility Type	**Alpha**	**Beta**
Freeway 70+ MPH	0.83	5.50
Freeway <70 MPH	0.40	5.00
Principal Arterial 55+ MPH	0.83	2.70
Principal Arterial <55 MPH	0.71	2.10
Minor Arterial 55+ MPH	0.83	2.70
Minor Arterial <55 MPH	0.71	2.10
Collector	0.71	2.10
Local	0.71	2.10
Centroid Connector	1.00	5.40
Ramp	0.71	2.10

For capacity calculations in the KYOVA model, a lookup table was used. The per lane link capacities are shown in **Table 22** below and can be found in Capacity_Equation.bin.

Table 22 – Lookup Table of Free Flow Capacities (per lane per hour)				
Facility Type	**CBD**	**Urban**	**Suburban**	**Rural**
Freeway	1500	1600	1700	1800
Principal Arterial	1000	1000	1200	1200
Principal Arterial w/TWLTL	1050	1050	1250	1250
Minor Arterial	700	800	800	1000
Minor Arterial w/TWLTL	750	850	850	1050
Collector	500	600	700	700
Collector w/TWLTL	550	650	750	750
Local	500	600	700	700
Local w/TWLTL	550	650	750	750
Centroid Connector	10000	10000	10000	10000
One-way Facility	700	800	900	1000
Freeway Ramp	800	1000	1100	1300

Model Calibration/Validation

This section describes the results of the model calibration and subsequent highway assignment results for the KYOVA travel demand model.

Table 23 – Model Calibration/Validation Summary				
Category	**Observed**	**Model**	**+/- %**	**FHWA Target**
Assigned Volumes by Facility Classification				
Freeway	360,500	358,145	-0.7%	+/- 7%
Major Arterial	694,107	673,989	-2.9%	+/- 10%
Minor Arterial	456,956	422,017	-7.6%	+/- 15%
Collector/Local	404,734	391,573	-3.3%	+/- 25%
Total	1,916,297	1,845,725	-3.7%	+/- 5%
Category	**Observed**	**Model**	**% RMSE**	**FHWA Target**
Assigned Volumes by Volume Group				
<500	7,549	12,977	179.5%	200%
500 - 1500	49,864	72,191	91.1%	100%
1500 - 2500	53,725	62,822	49.8%	62%
2500 - 3500	51,100	51,757	40.9%	54%
3500 - 4500	72,130	72,591	25.5%	48%
4500 - 5500	81,089	75,128	42.7%	45%
5500 - 7000	112,557	106,823	30.2%	42%
7000 - 8500	155,002	147,788	23.2%	39%
8500 - 10000	144,567	132,923	22.9%	36%
10000 - 12500	155,186	148,965	21.0%	34%
12500 - 15000	251,266	226,618	29.1%	31%
15000 - 17500	224,047	223,969	25.4%	30%
17500 - 20000	75,898	61,605	23.7%	28%

Category	Observed	Model	+/- %	FHWA Target
> 20000	482,317	449,569	19.2%	26%
Total	1,916,297	1,845,725	33.7%	35%
Category	**Observed**	**Model**	**+/- %**	**FHWA Target**
Screenline Summary				
Screenline 1	50,266	51,650	2.8%	+/- 5%
Screenline 2	63,202	61,664	-2.4%	+/- 5%
Category	**Observed**	**Model**	**+/- %**	**FHWA Target**
Other Summaries				
Lawrence VMT	1,337,060	1,376,260	2.9%	5%
Cabell VMT	2,434,426	2,500,637	2.7%	5%
Wayne VMT	1,079,480	1,132,490	4.9%	5%
Total VMT	4,850,966	5,009,387	3.3%	5%
RMSE	--	33.7%	--	< 35.0%
R²	--	0.887	--	> 0.800

Future Year Modeling

Future year modeling in the KYOVA model is similar to the 2010 base year modeling, with the primary difference being the roadway network and socio-economic data selected. Four future years are used in the KYOVA model: 2018, 2020, 2030, and 2040.

The current model has three future year networks: the baseline, the existing plus committed (E+C), and the metropolitan transportation plan (MTP). The MTP is also referenced as the LRTP in some of the model attributes.

Improvements for the existing plus committed (E+C) and the metropolitan transportation plan (MTP) were identified as a part of the existing MTP work.

Socio-economic data control totals along with specific TAZ allocations were developed by Michael Baker as part of this project. Documentation of this information is available under separate cover.

Table 24 – Model Socio-Economic Data Projections					
Attribute	2010	2018	2020	2030	2040
HH1_V0	5161	5200	5203	5252	5294
HH1_V1	16352	16493	16527	16713	16888
HH1_V2	3124	3151	3154	3186	3216
HH2_V0	1598	1608	1609	1626	1637
HH2_V1	7901	7970	7987	8088	8174
HH2_V2	21208	21439	21496	21791	22079
HH3_V0	655	658	658	664	667
HH3_V1	2571	2584	2588	2620	2637
HH3_V2	10483	10590	10612	10759	10888
HH4_V0	731	732	732	743	744
HH4_V1	2212	2228	2229	2251	2268
HH4_V2	11536	11673	11706	11895	12065
WK0_HH	30728	28612	28678	29025	31761
WK1_HH	30547	29024	29095	29465	31643
WK2_HH	19446	18887	18934	19212	20236
WK3_HH	2817	2778	2783	2825	2941

Students	48298	48740	48848	49403	49953
Total HH	83544	84359	84559	85580	86595
Total POP	201250	203120	203586	205915	208251
Agr	10231	10826	10976	11722	12467
Mfg	13381	14013	14172	14962	15738
Ret	11229	12757	13136	15042	16730
Off	9131	10473	10806	12479	14009
Ser	38308	39517	39817	41329	42718
Total Emp	82280	87578	88909	95532	101662
School Enroll	48250	48691	48798	49353	49905

External station projections were based on external station projected growth from the old model, and conversations with the Kentucky Transportation Cabinet regarding shared external stations.

Table 25 –External Station Projections							
Station	Location	County	2010 AADT	2018	2020	2030	2040
9001	US 52 N	Lawrence	9120	10350	10690	12530	14680
9002	OH 522	Lawrence	660	730	750	850	960
9003	OH 93 N	Lawrence	1800	1990	2040	2310	2610
9004	OH 141	Lawrence	730	810	830	940	1060
9005	OH 7 E	Lawrence	3120	3540	3660	4290	5020
9006	WV 2 E	Cabell	6000	6810	7030	8240	9660
9007	Mason Rd	Cabell	1640	1810	1860	2100	2380
9008	I-64 E	Cabell	32500	37490	38850	46430	55500
9009	US 60 E	Cabell	9000	10220	10550	12360	14490
9010	Bulls Gap	Cabell	700	770	790	900	1020
9011	WV 10	Cabell	3500	3970	4100	4810	5630
9012	CR 21	Wayne	300	330	340	380	440
9013	WV 37 E	Wayne	800	880	910	1030	1160

9014	12-Pole Creek Rd	Wayne	300	330	340	380	440
9015	US 52 S	Wayne	6600	7490	7740	9070	10630
9016	WV 37 W	Wayne	9300	10560	10900	12770	14970
9017	I-64 W	Wayne	27500	31720	32870	39290	46960
9018	US 60 W @ CL	Wayne	9400	10670	11020	12910	15130
9019	US 60 W @ River	Lawrence	34000	38600	39850	46700	54740
9020	OH 93 S @ River	Lawrence	10500	12110	12550	15000	17930

Operating the KYOVA Travel Demand Model

The KYOVA model interface was developed using GISDK to develop a dialog box that steps through the entire model process. Using the interface, the user can complete an entire model run. This section documents how to operate the individual portions of the model process and how to use the modules contained within it.

NOTE: Before launching the model interface, the street network and any other related model files must be closed. The interface will need exclusive access to these files. If network changes are needed, make the changes first, then close the network, and then launch the interface.

NOTE: All items mentioned here are in TransCAD 5.0, Build 1880. Due to software differences between TransCAD versions, the model may not operate properly if a different version of TransCAD is used.

Installing the KYOVA Travel Demand model

The KYOVA model can be installed to run either on a server or a local hard drive.

Launching the Interface through the GISDK Menu

- To launch the KYOVA model interface, first make sure the network, TAZs, and other model files are closed.

- In TransCAD 5.0, go to the menu for "Tools" and select "Setup Add-ins." A window similar to **Figure 4** will appear.

Figure 4: Setup Add-ins Interface
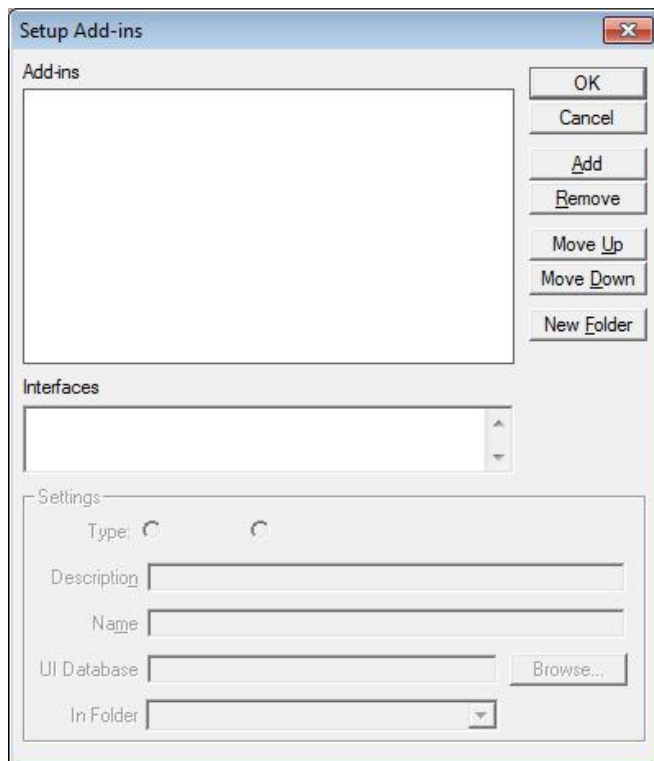
- Select "Add" and fill in the information similar to what is shown in **Figure 5**. Under "Settings," click on "Macro," type "KYOVA Model" (or something similar) in the *Description* field ("KYOVA

Model" can be anything you want it to be in the Description field) and "KYOVA Model" in the *Name* field ("KYOVA Model" MUST be in the *Name* field and is case sensitive). Click on the "Browse" button and browse to the UI database (kyova_ui.dbd). Click "OK".

Figure 5: GISDK Add-in Interface
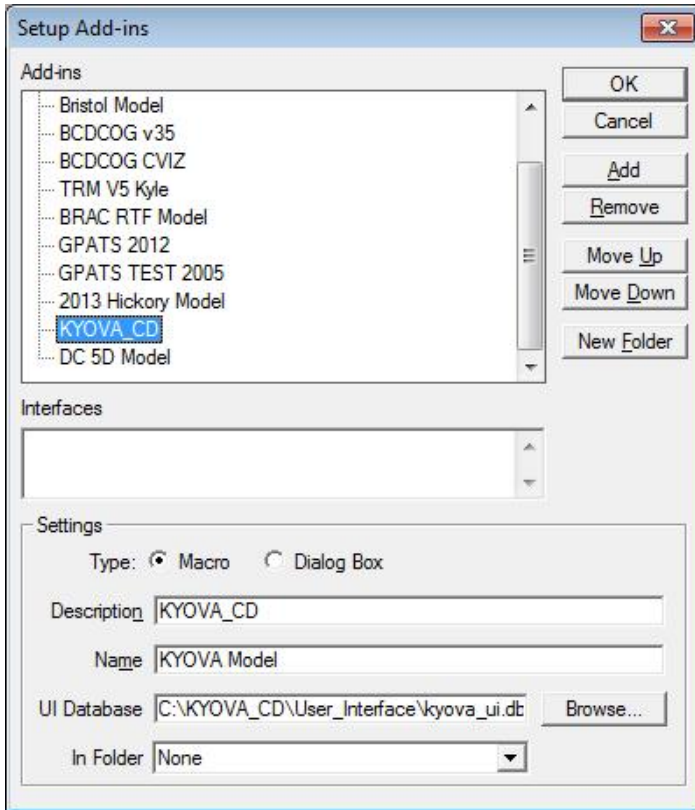
- You can now launch the KYOVA interface anytime by clicking on "Tools → Add-ins → KYOVA Model."

KYOVA Interface

When the KYOVA model is initially launched, an interface like the one shown in **Figure 6** is the typical result. To load a model scenario, click on the "Load" button and browse to the location of the scenario you wish to open (a scenario file contains all of the location information for the input and output files as well as certain parameter information including the year and network alternatives). The KYOVA interface contains a number of buttons that serve different functions in the running and management of the model. These buttons can best be broken down into the following categories: scenario settings, 4-step model settings, and maps and utilities. Each of these categories is described in detail below.

Figure 6: KYOVA model Interface
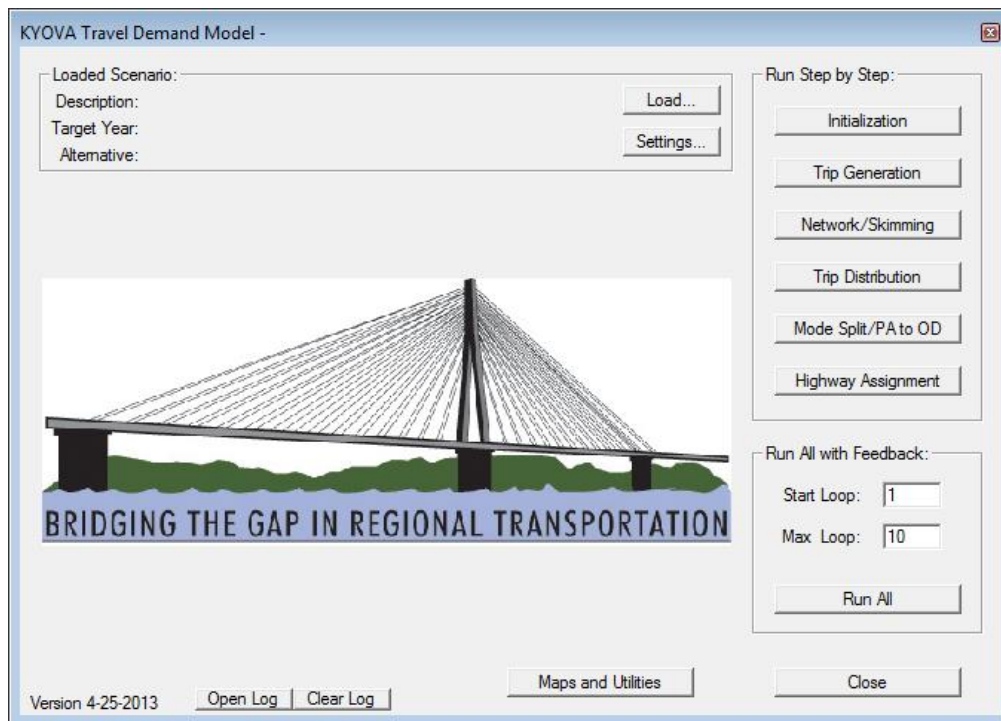
Scenario Settings

Each forecast year (2018, 2020, 2030 and 2040) is treated as a scenario in the KYOVA model. The TransCAD network has been developed so that both the base and forecast year facilities are included in one model file, and are managed by a Future Year Road Projects Tool. This allows for network editing on the base year data to automatically apply to the future year network(s) as well. When a scenario year and network is selected, the model implements changes to the roadway network to represent highway projects in the model. With this framework, any network edits or corrections made for one scenario are easily implemented for all subsequent years and scenarios. This methodology allows for easy management of roadway projects and a flexible environment for implementing several roadway improvements on a single corridor, such as a roadway widening in 2018 and then another widening in 2027. The model interface includes a file setup for scenarios that can be saved and loaded later to simplify the model setup process and allow for quick transitions between different test alternatives.

Model runs are managed by scenarios. These scenarios control which files and settings are used in the current application of the model. Scenarios are edited using the scenario settings interface which can be accessed from the main menu by clicking on the "Settings" button. **Figure 7** shows the scenario settings interface.

Note: You can load a scenario from the main interface screen by clicking on the "Load" button. This bypasses the scenario settings screen if you do not need to make any changes to the file settings.

The scenario settings interface has three main sections (tabs): Scenario, Input, and Output.

- The starting screen is the Scenario tab. On this screen you can load a scenario file, give that file a description name, pick the target year you're running the model for, and choose which network alternative you wish to use for the scenario.

- Select the year to be modeled under "Target Year."

- Select the network to be modeled under "Network Alternatives."

- The second tab is the "Input" tab. This is the location where you specify which files the model will refer to for the scenario you have set up. See **Figure 8** for the "Input" screen.

- The third tab is the "Output" tab. This is the location where you specify the filenames for the files the model creates during the run. See **Figure 9** for the "Output" screen.

- To change a file (on the "Input" or "Output" tab), go to the appropriate tab and click on the button for the file you want to change (such as "Master Network").

- When you are done with the settings, you can save any changes to the same scenario by clicking the "Save" button. You can save the settings as a completely new scenario by clicking the "Save As" button, and you can go back to the main interface screen (without saving) by clicking the "Return to Main Menu (Don't Save)" button.

- At any time you can export the file paths to a text file by clicking on the "Export File Paths" button.

Figure 7: Scenario Settings Interface
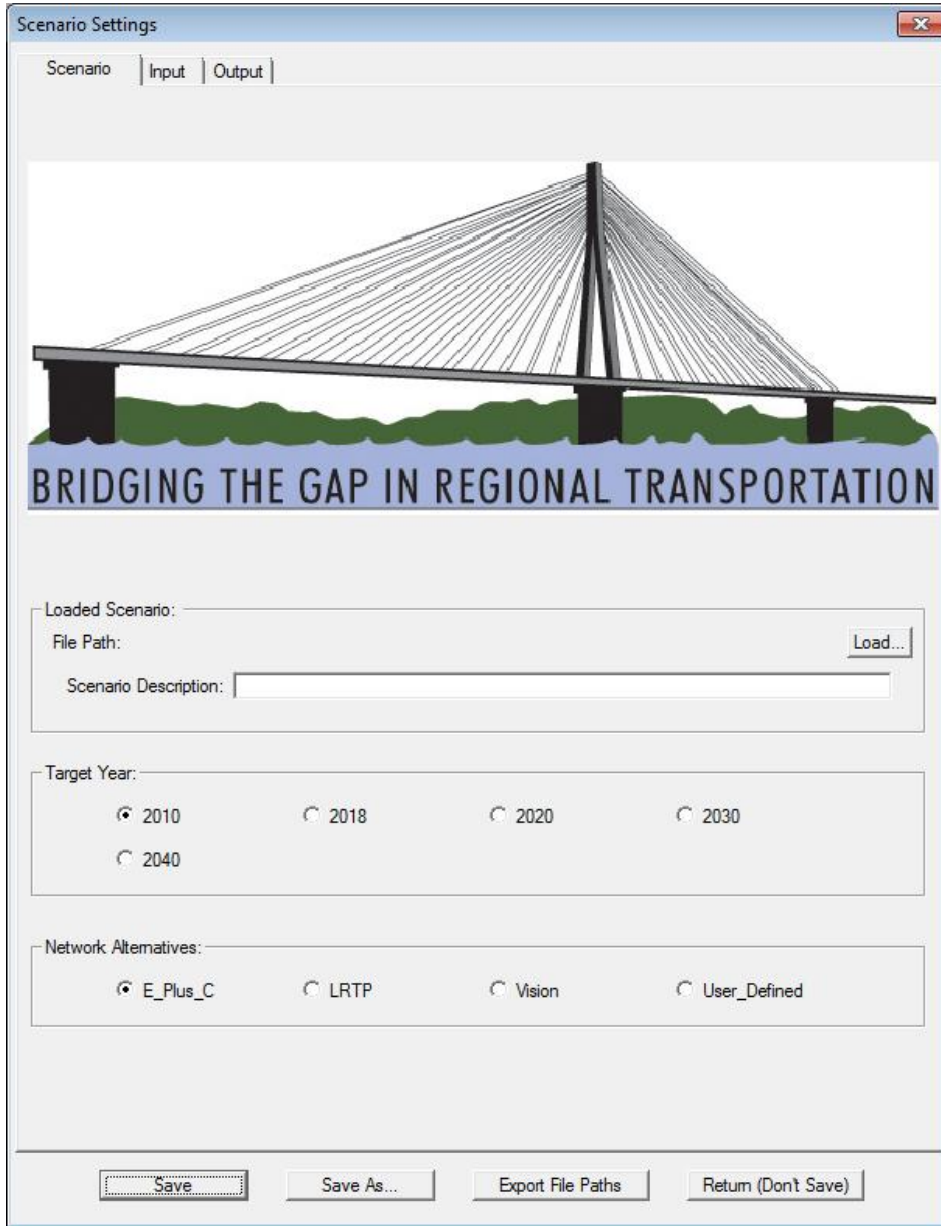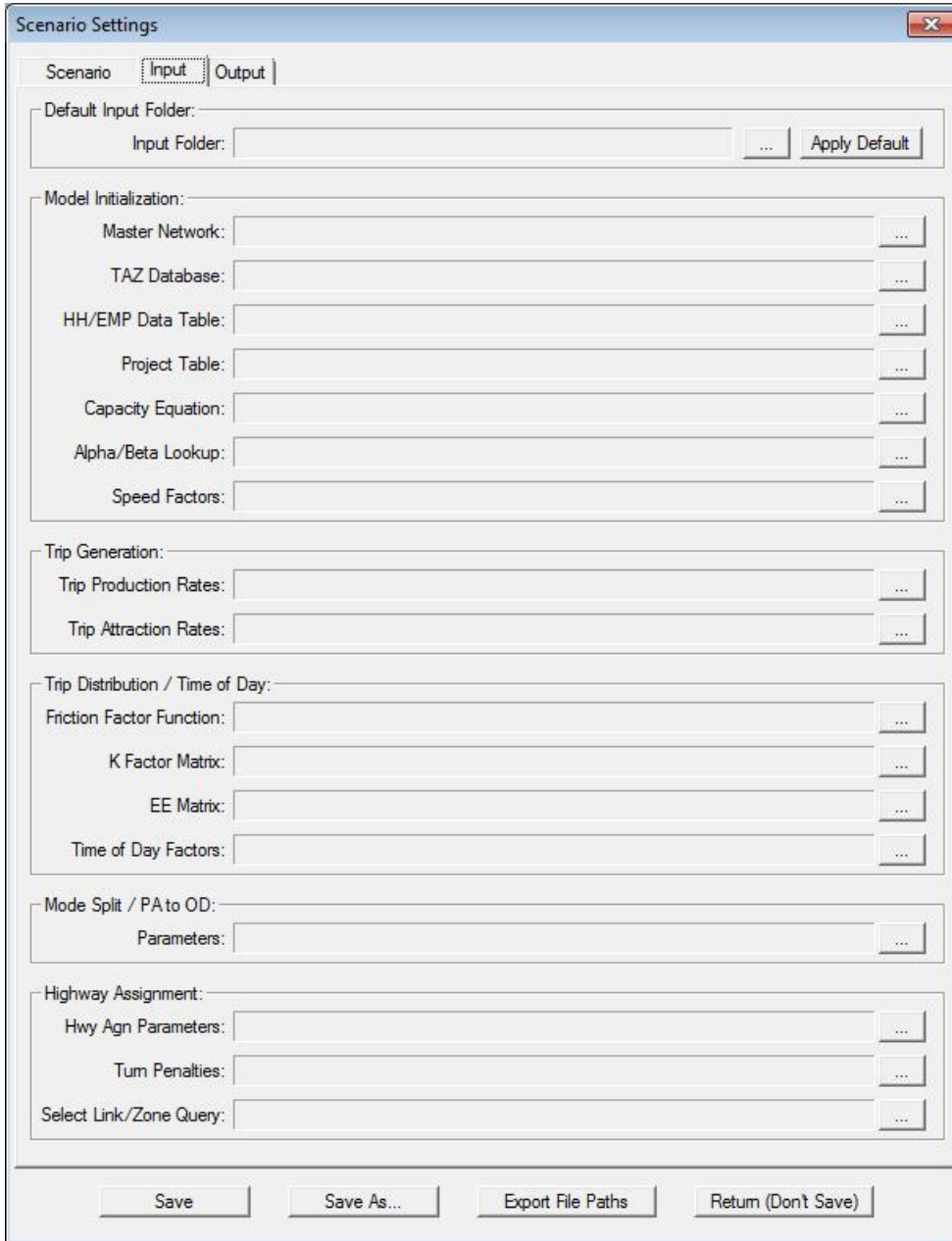
Figure 8: Input Files Tab

Figure 9: Output Files Tab

Changing File Paths

The KYOVA model is set up with the following directory structure:

- KYOVA_CD
  - Data Development Files

- o Input
- o Output
- o Scenarios
- o User_Interface

As long as this basic structure is followed, the KYOVA model has the capability of changing the file paths for all of the file settings in the model. This is useful in situations where the model has been moved to a new server or directory, but none of the internal files have changed.

- To update file paths for Input files, first go to Settings and click on the button next to the "Input Folder" heading at the top.
- A window similar to **Figure 10** will appear.
- Simply browse to the location where the new KYOVA_CD file is located, for example, C:\Projects\KYOVA_Model\
- The model will change all of the file settings to reflect the new location.
- You can click on the "Apply Default" button to shorten the file paths.
- Save a new scenario that has the file settings with the new location for easier loading in the future.
- To update file paths for Output files, simply follow the same steps outlined above.

Figure 10: Browse for Folder
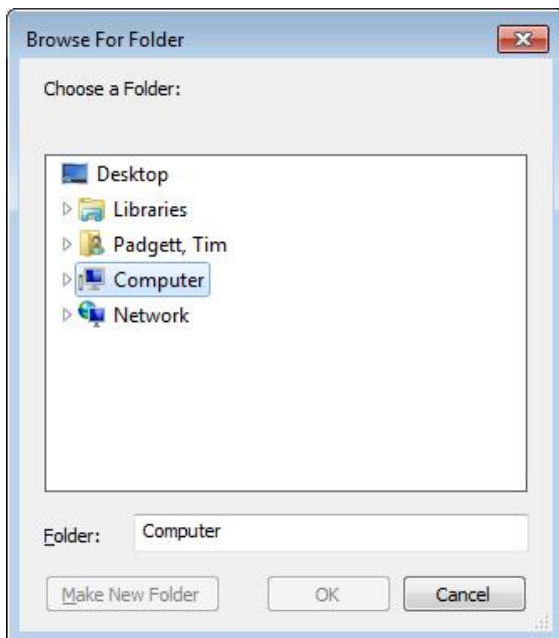
Running the Model

The KYOVA model can be run by either stepping through the individual steps of the model or by running the model steps all together. Each of these steps along with a button for running the whole model can be found on

the main interface screen. If you want to run the entire model from start to finish, after a scenario has been created or loaded, simply click on the "Run All" button near the bottom right of the interface. If you want to go through each of the steps individually, you can click on each step in succession.

Under the "Run All Steps with Feedback" section, the starting feedback loop and the maximum feedback loop can be specified, if desired. By default, the maximum number of feedback loops is set to 10. A typical model run usually converges in five loops. A progress bar will be displayed on screen during the model run to show the progress of the model run.

The "Start Loop" can also be specified. This allows you to resume a partial run conducted earlier. For example, if you finished your previous model run at Loop 2, you can set the "Start Loop" as 3 and click the "*Run All*" button. The model will resume the run at the beginning of loop 3.

At the completion of the model run, a message box will be displayed indicating that the model run with feedback loops is completed successfully.

Model Version and Logs

The model script version is displayed at the bottom section of the main user interface. The "*Open Log*" button can be used to open the log file using the Notepad or other text editing program. The log file records time stamps for activities such as loading and saving the scenarios, and starting and completing time of each model steps of the model runs. The MSA feedback convergence checking statistics are reported in the log file. Other information that could assist in trouble shooting will also be recorded in the log file. The "*Clear Log*" button can be used to erase the contents of the log file if it is getting too long.

Maps and Utilities

The RIC model has built-in capabilities for performing additional tasks. These tasks have been organized together in the "Maps and Utilities" button on the main interface.

To run the utilities interface, select the "Maps and Utilities" button from the main window. A window similar to **Figure 11** will appear.

- The "Future Year Project Tools" tool is described in a later section.

- The "MOVES Pre-processor" and MOVES Post-processor" are described under separate documentation.

- "Show Daily Volume/LOS Map" – Clicking on this button will produce a color coded LOS map based on the <u>last run completed</u>. Model volumes are copied to the Input Network file after each run so the user needs to be careful when using this function to make sure that the output information is as expected. This button should only be used immediately after a model run to get a general idea of LOS information.

- "Remove Progress Bar" — Clicking on this button will remove the progress bar from the screen if the model crashes or stops in the middle of a step. This allows the user to go back to the main interface screen without having to shut down TransCAD (and then restart) to get rid of the progress bar.

- "Close All Files" — Clicking on this button will close all active windows in the TransCAD environment. This is useful if you have a lot of windows open and want to exit quickly.

Figure 11: Utilities Interface
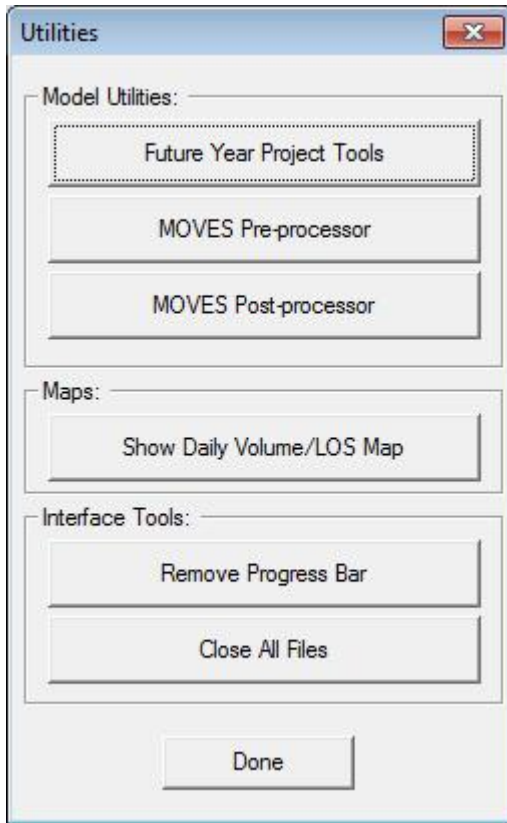
Editing Zone Data

Edits of zone data would include changes to the housing and employment data for a TAZ or group of TAZs. Reasons for changes to TAZ data would typically include correcting base year data or revising the future year forecasts. The KYOVA project folder contains a TAZ file in the folder "Input" that serves as the base for each of the model years. Individual TAZ Socioeconomic Data files are contained in the "Input" folder as well. These TAZ files, labeled "SEDataxxxx_*Date*.bin," contain all of the socioeconomic data that drives the model. This information is copied to the base TAZ file after each run.

The Traffic Analysis Zones section of this report describes the contents of each of the fields within the SE Data files. Once TAZ data edits have been made, the files should be closed before launching the model interface.

Editing Network Data

The KYOVA model network contains both existing and future year links. It is a "master" network and all model years are "built" from it with the use of selection sets. The Highway Network Database section of this report describes the highway network development along with the content of each of the fields within the highway network database.

Instead of putting all of the attributes for the future year links in the highway network database, a different procedure utilizing a project file was utilized. While the actual linework associated with *future* year links is contained in the highway network database, all attribute data associated with those links is contained in a project file that is then transferred to a working set of attributes in the highway network database for the particular year and scenario that is being run. This method reduces the number of columns in the highway network database to a very manageable number by putting all project attributes in the project file. It also allows the user to quickly tell which projects are coded by simply looking at the project file. The fields contained in the project file can be seen in **Table 26**.

Table 26 –KYOVA Project Database	
Field Name	**Description**
SORT	Hold over attribute from model development – NOT USED
PRJ_ID	Project ID that Connects the Project File to the Network File
BORN_YEAR	Year of Project
E_Plus_C	Project Alternative for E+C – A "1" signifies that the project is included
LRTP	Project Alternative for LRTP – A "1" signifies that the project is included
Vision	Project Alternative for Vision – A "1" signifies that the project is included
User_Defined	Project Alternative for User Defined – A "1" signifies that the project is included
TIP_ID	Reference TIP number
LRTP_ID	Reference LRTP number
Route_Name	Name of Facility
From	Project Begin Location
To	Project End Location
Comment	Comment
In_Network	Flag to signify that the project is included in the network (1 = Yes, 0 = No)

Fac_Type	Facility Type Identifier
Posted_Speed	Posted Speed
AB_Lanes	Number of Lanes in the AB Direction
BA_Lanes	Number of Lanes in the BA Direction

Two methods are available to edit data for a network link:

To edit data for a base year link, first the KYOVA model interface must be closed. The network can then be opened in TransCAD. It should be noted that when editing network data, it is important that fields that require data for proper analysis do contain data.

- If adding a new line to the base year, be sure to provide the following data in the network fields:
    - Y10_In_Network
    - Y10_Fac_Type
    - Y10_Posted_Speed
    - Y10_AB_Lanes
    - Y10_BA_Lanes

All other fields are unnecessary to successfully run the model or are automatically calculated. **Table1** lists the highway network attributes in more detail.

- If lines are being split, be sure to use the map editing toolbox ("Tools -> Map Editing Toolbox"), and have the settings configured so that attributes are copied into both new lines.

- If lines and nodes are only being moved, then it is not necessary to edit the field data, since it will not change.

To edit data for a future year link, click the "Maps and Utilities" button on the main KYOVA interface and then click the "Future Year Project Tools" button. The future year project tool can be used to accomplish the following tasks:

- Query a link to see all of the projects associated with it

- Modify attributes of a particular project

- Delete a particular project and remove its association with network links

- Enter a new project and define its association with network links

- Redefine network links associated with a particular project

If you do not have a scenario open when you activate the future year project tool, you will be reminded to open a scenario. Also, if you do not have the RIC network open, the network in the specified scenario will be opened when you click on the Future Year Project Tool. **Figure 12** shows the project coding tool and **Figure 13** shows the associated future year map.

Note: If you are adding a project that requires new links, this should be completed prior to opening the future year project tool. **Chapter 24** of Caliper's *TransCAD User's Guide* offers more instructions on geographic file editing.

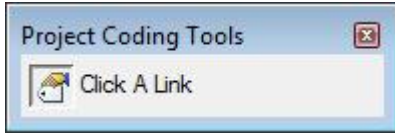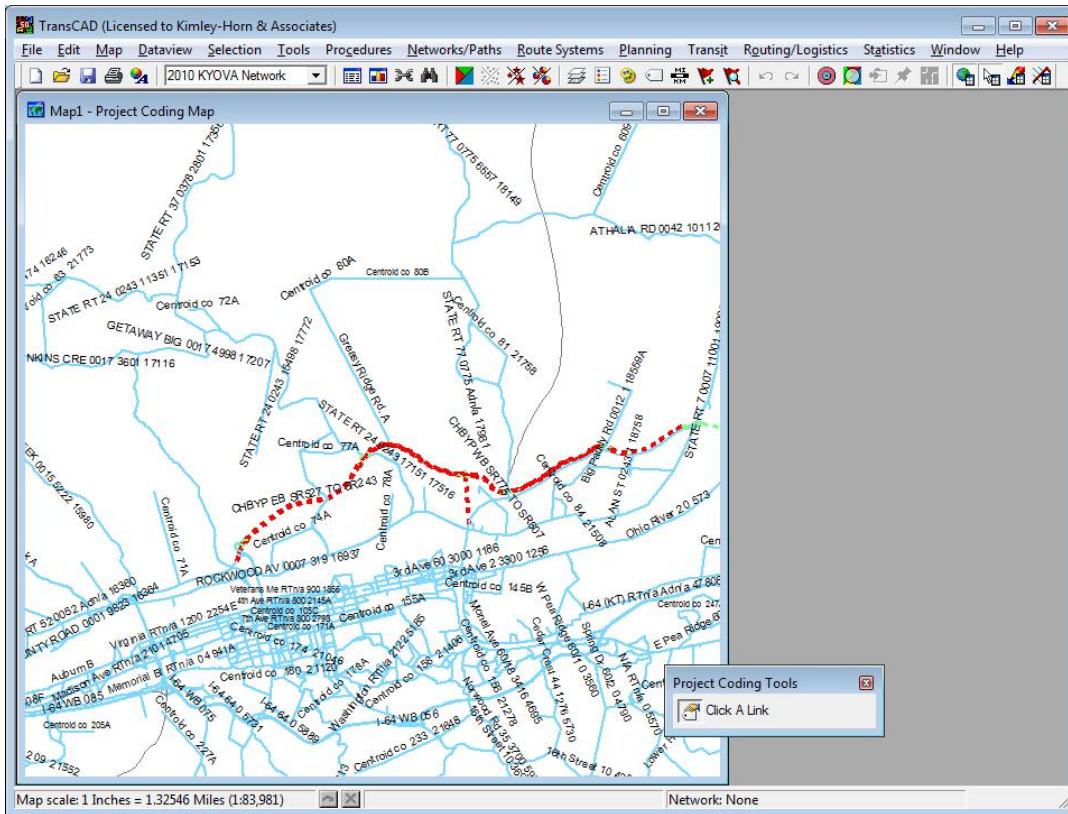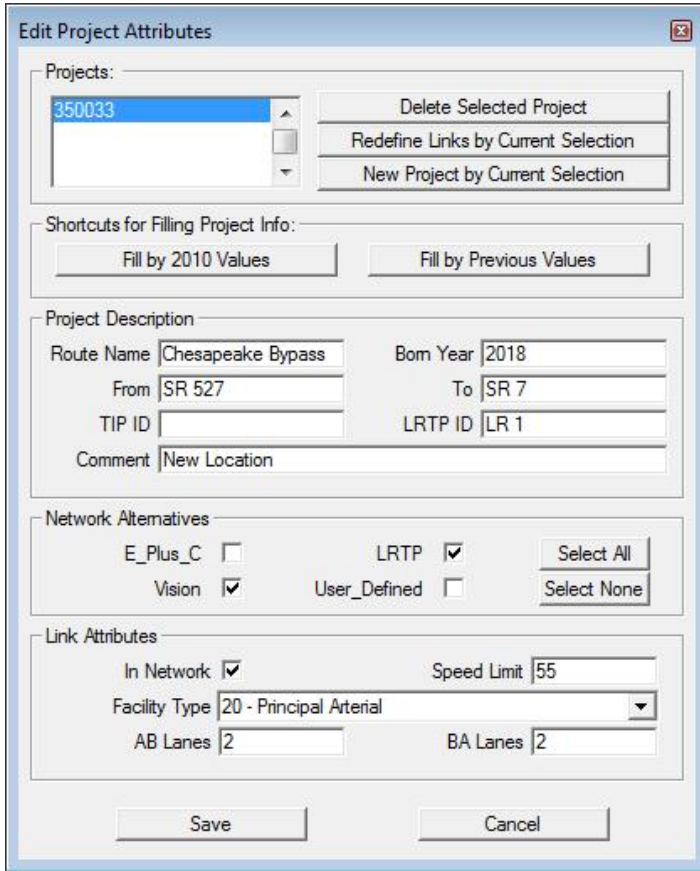**Figure 12: Future Year Project Link Tool**

Figure 13: Future Year Project Map

By clicking on the "Click A Link" tool and then clicking on a link in the map, the future year project toolbox will appear, similar to **Figure 14.**

Figure 14: Future Year Project Toolbox

To add a new project, first activate and use any standard TransCAD tools to select the set of links that will be associated with the new project (like the "Select by Pointing" tool on the standard tools window). After the new links have been selected, click on the "New Project by Current Selection" button. A temporary project ID will be assigned as a placeholder. This can be seen in **Figure 15.**

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Figure 15: Future Year Project Toolbox

At this point, complete the information for the project in the toolbox fields. After you have finished inputting the information, select "Save" and this will add the new project to the project table. This can be seen in **Figure 16.** The PRJ_ID will be automatically assigned based on the year field and the associated links will be updated in the highway network database.

Figure 16: Project File

When a target year of 2040 is picked in the scenario settings, the model will select the information from these links based on the PRJ_ID and fill in the correct information for the 2040 run.

A link can have up to 6 projects associated with it. Multiple projects associated with a link could occur, for example, when a road is widened from 2 to 4 lanes in 2009 and then is widened again to 6 lanes in 2040. The first widening project would be associated with 2009 and the second widening project would be associated with 2040.

In addition to adding new projects, existing projects can be modified by clicking on the "Redefine Links by Current Selection" button. By clicking on a link that has already been defined (the attributes have been entered), and then clicking on additional links, clicking on the "Redefine Links by Current Selection" button will update the newly selected links with the same project information as the link that was originally selected.

The user also can delete a particular project and remove its association with network links by clicking on the link, highlighting the project ID number in the future year project toolbox (**Figure 15),** and then clicking on the "Delete Selected Project" button. A screen similar to **Figure 17** will appear and you will be asked to confirm deleting the selection. If you click yes, the project will be deleted from the project table and the association to all the links will be removed.

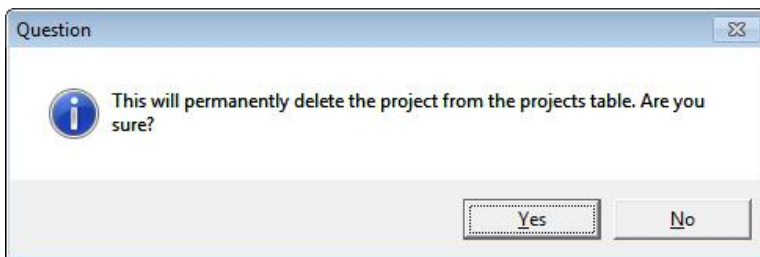**Figure 17: Delete Confirmation Prompt**
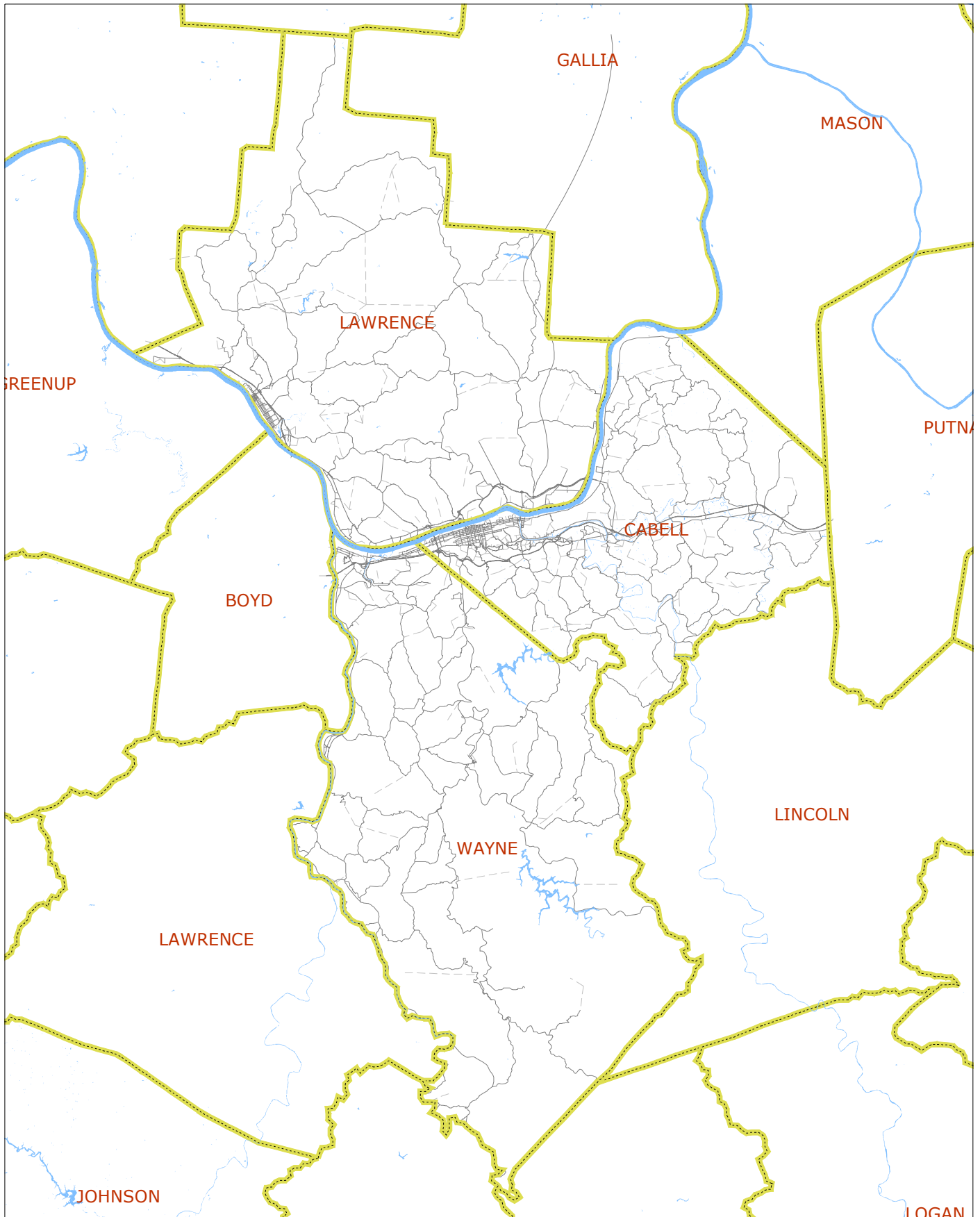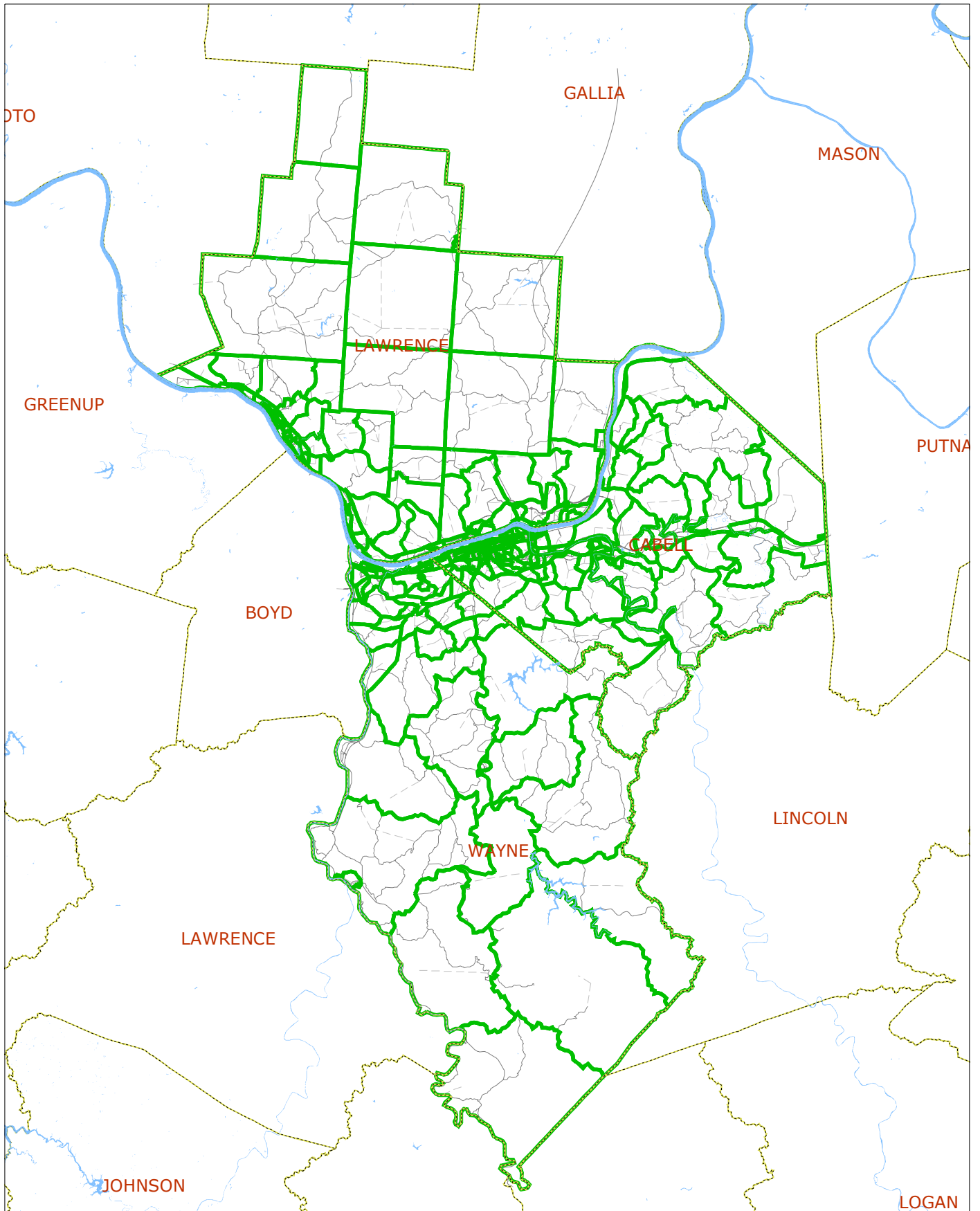
Figure 1 - Model Study Area and Network

Figure 2 - Model TAZ Structure

Figure 3 - Model External Stations