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A Contrast of Statewide Models for Small, Medium, and Large States

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Travel demand modeling at a statewide level typically follows established procedures that are the same as for those applied in urban models. The major difference is in the level of detail and the characteristics of the model component attributes. Small states can be treated as a large urban area model. Statewide models for medium size states can be developed by combining urban or regional models and in-filling the rural areas. Larger states can also take advantage of MPO models as a source of data. The models can be built by supplementing the urban information with new data collected in the rural areas. In the larger states, rural areas tend to cover a much larger geography than the urban areas.

To establish a framework for the relative characteristics of models developed for different size states, this paper compares the characteristics of statewide models developed for three states considered to be small, medium, and large. They are Vermont, Missouri, and Texas, respectively.

DEMOGRAPHIC COMPARISONS

Vermont

Located in Northern New England, Vermont is characterized by rolling and mountainous terrain. Covering an area of 9,249 square miles and with a 1990 population of approximately 652,758, the state has an average population density of 63 persons per square mile. Vermont has 2,452 miles (93 percent) of roads classified as rural and 176 miles (7 percent) classified as urban.

Missouri

Missouri is A mid-west state characterized by a level to rolling terrain. The state is 68,945 square miles in area and, in 1990, had an approximate population of 5,117,000. The average population density for the state is 74 persons per square mile. The state has 30,650 miles (95 percent) of road classified as rural and 1,733 miles (5 percent) classified as urban.

Texas

The largest of the contiguous United States, Texas is located in the south central section of the country. Texas is 261,914 square miles in area and has a generally level terrain. In 1990, the approximate population was 16,986,510. The average population density for the state is 69 persons per square mile. Texas has 68,093 miles (88 percent) of its roads classified as rural and 10,434 miles (12 percent) as urban.

These are very broad statistics which describe each state's demographic and transportation system

characteristics. Clearly, the concentration of activity centers has a significant impact on travel patterns and the way in which each state's travel demand model is structured. Table 1 presents additional data that characterizes the attributes that are typically considered in model development. The percentages presented in Table 1 are calculated with Texas as the basis of comparison.

MODEL APPLICATIONS

Each of the three states being compared has a different reason for developing a statewide model. The use to which the models will be applied dictates the basic character and configuration of its structure.

Vermont

The Vermont Agency of Transportation (VAOT) implemented a planning initiative whereby the state's 12 Regional Planning Commissions (RPC) would have an early input into the improvements to the state's transportation system and the development of a statewide Transportation Improvement Program (TIP). The intent was to provide the RPCs with tools they could use to plan and evaluate transportation improvement alternatives in their respective regions. The basic tool was a statewide travel demand model, structured so that each region could use the model to test alternatives for transportation systems and land use configurations. Recommendations developed through this approach by each RPC are then passed upward to VAOT for evaluation and prioritization on a statewide level.

An RPC can modify land use or transportation infrastructure in its own region. Because of the compact size of the state, the RPC can run the entire statewide model and not be concerned with estimating travel at the externals defined by the cordon of the RPC study area. The RPCs can make individual changes to their copy of the model for evaluation purposes, but cannot change the base model maintained by VAOT.

Missouri

The Missouri Department of Transportation (MoDOT) determined a need for a statewide travel demand model to support transportation planning efforts. Basic requirements of the model are that:

- it has the capabilities to estimate current and forecast future travel under a variety of conditions and assumptions; and

- it provides assistance for evaluating statewide corridor priorities.

A two-way data exchange with the existing ArcInfo and Oracle databases is also an important feature of the demand model for sharing existing and forecast travel data. The objective is to establish a process that can adequately address mandated policy and overall system-level analysis for planning and programming.

The travel demand model development was envisioned as a two-phase process. The first phase would provide traffic data for a number of corridor transportation improvements to be used in a needs study of the I-70 corridor, from Kansas City to St. Louis. The corridor model would also serve as a

demonstration of the capabilities and validity of a statewide model to be developed in the second phase.

At the conclusion of the first phase, MoDOT will evaluate the travel demand model and make recommendations for improvements, if any, prior to moving to the second phase.

The planned approach was to build a statewide model with a greater traffic analysis zone and network level of detail in the I-70 corridor and a broader based zone and network configuration in the rest of the state. This would reduce the problems associated with locating and forecasting traffic at external stations. Subsequent to the completion of the I-70 corridor analysis, the model in the rest of the state would be upgraded to provide the capability to conduct analyses in other corridors in the state. Because of the automated processes used to develop the corridor model, the detailed information required for the remainder of the state was carried along in the database, thereby expediting the completion of the statewide model.

Texas

The Texas Department of Transportation (TxDOT) currently builds and maintains travel demand models for individual urban areas in the state. These traditional three-step models use a custom trip generation model (TRIPCAL5), a custom trip distribution model (ATOM2), and a capacity restraint assignment. The models provide TxDOT with a mathematical tool, with quantifiable accuracy, that can be used to forecast travel demand based on household and employment characteristics. TxDOT has a need to expand the coverage of its travel demand modeling process to include consideration of different passenger and freight modes and to quantify the interaction between modes. This capability is to be provided through the Texas Statewide Analysis Model (SAM).

Included in the project is a component in which data to identify the impacts of the North American Free Trade Agreement (NAFTA) traffic on the Texas Highway Trunk System are developed and evaluated. Part of the justification for developing the SAM is a legislative requirement for TxDOT to analyze the increase in commercial traffic on Texas highways due to NAFTA. The legislation also directed TxDOT to identify the highways that need to be designated for construction, expansion, and maintenance as a result of NAFTA.

MODEL STRUCTURE

Each of the states has a different model structure because of the intended applications. The Texas and Missouri models were under development at the time of this writing, and some of the model components might change in the final version.

Vermont

The state is comprised of 12 Regional Planning Commissions with four MPOs. One MPO has a working model. The VAOT statewide model traffic analysis zones are based on Block Group census geography. The model has 622 internal and 98 external zones.

The roadway network was taken from the Vermont Geographic Information System (VGIS) and includes Functional Classifications of collector and higher.

Trip generation cross-classification data were developed from a mail out/mail back household survey of household characteristics and travel.

Trip distribution was by gravity model and mode choice was determined by the household data. Travel time factors were developed from survey trip length information.

Roadside intercept O&D surveys were conducted at 25 cordon locations, which represent 95 percent of the traffic crossing the state line.

Of the 12 RPCs, four have bus service. Only intercity bus trips were considered. Trip assignment was by the equilibrium technique.

One RPC had a fully operational model. The zone structure and accompanying demographic data were aggregated to a level consistent with the rest of the state and integrated with the statewide zone system.

Trip purposes are HBW, HBS, HBO, NHB, and Truck. Based on roadside survey data, trucks were estimated to be approximately 19 percent of the NHB purpose.

The travel demand software used in the model is TRANPLAN. Documentation and training workshops for users was an important component of the model process.

Missouri

The state has six Metropolitan Planning Organizations (MPO) that currently run and maintain urban models. The MoDOT model incorporates a zone structure of Block Groups and Block Numbering Areas (BNA) for the rural areas, and aggregations of existing Traffic Analysis Zones in the urban areas. Current plans call for the MoDOT model to have 1100-1500 internal and 120-150 external zones. The structure for the Missouri statewide model is illustrated in Figure 1.

The highway system is based on the state's ArcInfo GIS system which features Oracle databases that contain most of the required attribute data. The model network includes minor collectors and higher in the rural areas and collectors and higher in the urban areas.

The model network was constructed by building MoDOT district level models from the ArcInfo/Oracle system. Then the district models are combined into a statewide model structure. There are 10 MoDOT districts which, in combination, cover all 115 counties.

Because of the large number of lines in the ArcInfo database, most traditional software packages cannot accommodate the line work. To overcome this problem, a custom network editing program was used to edit the ArcInfo line work, including local roads. Table 2 presents a comparison of GIS line work and the final model link counts for urban and rural areas in one MoDOT District. This interactive editor allows the network editing to consider the inclusion of local roads in the model structure where needed

for network continuity. Thus, in addition to collector and higher classified roads, local roads can also be included in the model. The network editor also attaches zones to the highway network and establishes one zone connector for each zone. Additional zone connectors are added later in the editing process. The availability of this network editor/GIS interface allows model networks to be developed quickly. In addition, because each district is initially developed as a separate model, network editing to the district models can be done concurrently rather than having one large network and model with access restricted to one user at a time. Subsequent to the editing process, the 10 district networks are combined into a statewide network.

Trip generation cross-classification rates are based on a small-sample survey of 400 rural households statewide. Approximately 1000 households were contacted to recruit and obtain 400 usable surveys.

Data were obtained from roadside intercept O-D surveys conducted by MoDOT within the most recent five year period (1992-1996). This information will be used in the base model calibration and validation. The majority of the interview stations were conducted at internal locations throughout the state.

Travel time factors for the distribution process will employ a combination of MPO data and results of the household survey.

Mode share will be determined by a combination of household survey data and information available from the MPOs. Only intercity transit travel will be modeled.

Trip purposes are HBW, HBO, and NHB. Trucks will also be treated as a purpose.

TRANPLAN was selected by MoDOT for the statewide model. Several training workshops are schedules to provide MoDOT staff with detailed exposure to the model and hands-on opportunities to apply them. The development of statewide modeling theory and operations manuals are integral components of the model development and application process.

Texas

The most complex of the three models being compared, Texas will be subdivided into1700-1900 internal and 250-300 external TAZs based on Census Designated Place (CDP) geography. Texas has 26 MPOs, 24 of which hacve. The passenger and freight models will be built on a platform that will be extensible, flexible, and will accommodate new modes without major restructuring. The SAM is planned as a multimodal and intermodal model with two major components, passenger and freight. The passenger component will model highway and rail systems while the freight component will model highway, rail, air, and water systems. The two model components will be integrated through common demographic and transportation systems databases. Figure 2 illustrates the model structure for the SAM.

The initial highway network description is represented by the Texas Highway Trunk System, which is basically the same as the National Highway System (NHS).

TxDOT has a customized trip generation program, TRIPCAL5, and a custom trip distribution model, ATOM2, that will be interfaced with their software of choice, TransCAD.

The passenger model and the freight model will differ in operation, but both will be tied to an integrated data base. Commercially available freight data bases and limited roadside truck intercept O&D surveys will be the basis for the freight model development, particularly for the NAFTA impact study.

Because of the short time-frame in which the NAFTA study had to be completed, a network was constructed from a GIS database and a truck trip table was developed using a trip matrix estimator.

Table 3 presents a summary of the model characteristics of the three statewide models.

STATEWIDE MODEL TECHNICAL CHARACTERISTICS

Because most modeling efforts over the past 30 years have focused on urban models, it is useful to look at the key differences between urban and statewide models that were encountered in the development of these three statewide models:

Model Applications

Statewide models are typically used to supplement the urban models by providing travel information and forecasts in the rural areas. By having travel forecasts at a statewide level planning, policy, and priority-setting activities can be more logically established.

Traffic Analysis Zones

The size and number of TAZs in a statewide model are dictated by the geographical area to be modeled. Urban areas in statewide model are typically represented by larger and fewer TAZs than would be found in an urban model.

Networks

The level of network detail in a statewide model is coarser due to the larger geographic area represented. The lowest level of functional classification is generally major arterial or minor arterial, depending upon the state. Smaller states tend to use a lower limit of the functional classification because of the need to have a detailed network that can adequately support the TAZ system and provide a reasonable level of connectivity. A key issue with building statewide networks, particularly those that are GIS based, is that some commercial travel demand software systems cannot accommodate the number of lines required to process and build a network. This requires building the network outside the model, linking the GIS line work into roadway segments that are readable within the limits of the software. Table 2 presents a comparison of the number of lines in a Missouri District GIS database and the resulting number of links in the network model built from the GIS.

Friction Factors

Friction factors, or travel time factors, which express an impedance to travel due to certain conditions, are different in a statewide model trip distribution compared to an urban or regional model. Key differences are found in trip length and trip length distributions. They are more pronounced in larger states and the friction factors are more difficult to calibrate. The urban model travel time factors might be useful as a starting point in some cases.

Trip Generation

Urban trip generation rates are likely to be represented by one set of cross-classification rates for trip productions and one set of regression equations for productions and attractions. A statewide model might have different rates for urban and rural areas.

Intrazonal Trips

The intercity and local travel issues reflect the geographic differences. In larger TAZ's, intrazonal trips are likely to be a higher
percentage of total travel in a statewide model than for an urban model.

Mode Split

Mode split is not usually an issue in statewide models. Public transportation is typically limited to intercity travel by bus, and sometime by rail.

External Travel

External travel is likely to be less difficult to estimate in a statewide model because of the traffic and O-D data typically collected at the state boundaries. However, where a statewide model has a large city bordering a large city in an adjacent state, such as Kansas City, MO and Kansas City, KS, cross-border traffic is more difficult to identify. In states that have a statewide model, the urban models can take advantage of the statewide model to better estimate the external travel at the urban area model cordons.

Trip Assignment

There can be a significant difference in trip assignment techniques between urban and statewide models, and even between statewide models for states of different sizes. Larger states might tend toward an all-or-nothing assignment for broader, corridor-level assignment needs. Smaller states that have analysis applications closely related to urban studies might require a type of equilibrium assignment for greater accuracy and reliability.

Computer Run Time

Because of the larger statewide systems, computer processing times might be slightly higher than urban models. With the capabilities of current software and ever-increasing computing power, this is becoming a non-issue. The exception might be the time it takes to use GIS line work to develop a model network. However, the conversion process is a one-time process and once the model network is created, process time is not excessive.

Calibration and Validation

Calibration and validation in a larger statewide model will be very similar, while in a smaller state, they could be two distinct and separate process.

CONCLUSIONS

There are a number of differences in the character and application of small, medium, and large statewide models. The greatest differences can be seen in the level of detail in the TAZ and network components of the models. The intended application of the models also has a significant influence on their basic structure. The uses of the models discussed here include development of state transportation improvement programs, the development of data for analysis of interstate mainline and interchange operations, and the establishment of an integrated multimodal and intermodal source of information for policy evaluations.

There was a significant reliance, in each of the statewide model developments, upon the use of GIS databases for the development of the model networks. The models also relied upon limited data collection efforts to supplement and validate data available from MPOs and commercial data sources. In Vermont and Missouri, statewide household O-D surveys were conducted. In Texas, roadside truck intercept surveys were conducted.

Due to the recent interest in statewide model development, what are considered to be state-of-the-art practices change with every new model being developed. Data sources and techniques are being refined to respond to, and accommodate the needs of, this latest phase of travel demand modeling.

TABLE 1 State Characteristics

Characteristic	Vermont	% Texas	Missouri	%Texas	Texas
Land Area, sq. miles	9,249	3.5%	68945	26.3%	261914
Land Area Rank in the U.S.	43rd		18th		2nd
Demographic					
Population	652,758	3.8%	5,117,000	30.1%	16,986,510
Households	271,214	3.9%	1,961,206	28.0%	7,008,999
Average HH Size	2.41	99.3%	2.61	107.7%	2.42
Average HH Income	$36,261	110.2%	$31,870	96.8%	$32,914
Total Employment	379,000	3.5%	3,244,000	29.8%	10,888,000
Roadways[1] - Rural Miles	280	12.7%	809	36.7%	2,204
Interstate	310	4.6%	3,052	45.2%	6,751
Other Principal Arterial	709	7.5%	3,397	36.1%	9,416
Major Collector	1,142	3.3%	17,938	51.2%	35,019
Minor Collector	10	0.1%	5,454	37.3%	14,636
Local	1	1.5%	0	0.0%	67
Total	**2,452**	**3.6%**	**30,650**	**45.0%**	**68,093**
Percent Rural Miles	93.3%		94.6%		86.7%
Roadways [1] - Urban Miles					
Interstate	40	3.9%	369	35.8%	1,030
Other Freeway & Expressway	14	1.3%	279	25.8%	1,083
Other Principal Arterial	56	1.7%	710	21.1%	3,372
Minor Arterial	61	3.2%	304	16.0%	1,897
Collector	5	0.2%	64	2.1%	3,047
Local	0	0.0%	7	140.0%	5
Total	**176**	**1.7%**	**1,733**	**16.6%**	**10,434**
Percent Urban Miles	6.7%		5.4%		13.3%

All Roadway Mileage - Total	**2,628**	**3.3%**	**32,383**	**41.2%**	**78,527**
Total Interest Trips (millions)	4.77	2.49%	15.78	82.5%	19.12

Figure 1 - Missouri Statewide Model Structure

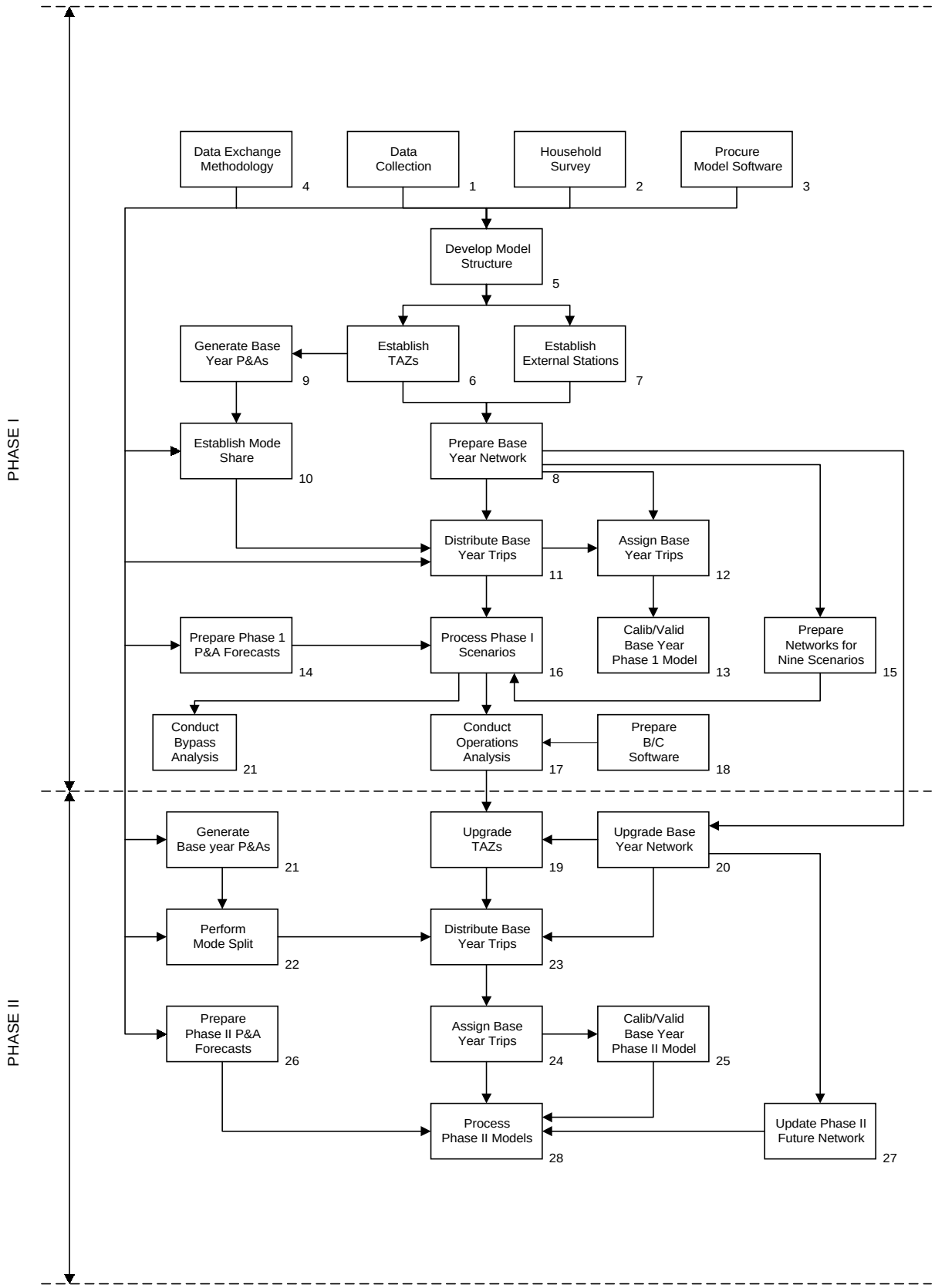

TABLE 2 Comparison of GIS Line Work and Model Links

	Missouri - District 6							
	Urban				Rural			
	GIS		Model		GIS		Model	
Functional Classification	**No. Of Lines**	**Miles**	**No. Of Links**	**Miles**	**No. Of Lines**	**Miles**	**No. Of Links**	**Miles**
Local	59,665	1,680	0	0	35,386	1,625	0	0
Interstate	1,779	105	0	0	399	34	0	0
Freeway	333	24	0	0	11	1	0	0
Expressway	0	0	0	0	0	0	0	0
Principal Arterial	4,619	129	0	0	921	45	0	0
Other Arterial	0	0	0	0	0	0	0	0
Minor Arterial	3,842	101	0	0	614	312	0	0
Collector	6,409	192	0	0	464	11	0	0
Major Collector	240	10	0	0	3,431	208	0	0
Minor Collector	6	1	0	0	1,077	71	0	0
Totals	**76,893**	**2,242**	**0**	**0**	**42,303**	**2,307**	**0**	**0**

Table 3 Statewide Model Characteristics

Characteristic	Vermont	Missouri	Texas
Internal TAZs	622	1100 - 1500	1700 - 1900
External TAZs	98	120 - 150	250 - 300
Avg. Square Miles per Internal TAZ	14.9	8.4 - 6.2	154.1 - 137.8
Avg. Population per Internal TAZ	905	4651 - 3411	9992 - 8940
No. of MPOs	4	6	26
Trip Purposes	6	4	
Trip Generation	Cross-Class	Cross-Class	Cross-Class[1]
Trip Distribution	GM	GM	GM[2]
Mode Split	Intercity Bus	Intercity Bus	Rail[3]
Trip Assignment	Equilibrium	Equilibrium	Equilibrium
Data Sources	Surveys Census	Surveys Census	Surveys Commercial Census

1. TxDOT has a custom trip generation program, TRIPCAL5.
2. TxDOT has a custom trip distribution program, ATOM2.
3. The TxDOT model passenger mode split is by auto and rail. The freight is by truck, rail, air, and water.