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16. Abstract The Texas Department of Transportation (TxDOT) developed the Texas Statewide Analysis Model (SAM) to provide analysis and forecasting capabilities of passenger and commodity/freight movements in Texas. The SAM provides data and results at a level that is more aggregate than that typically accomplished within urban areas in their travel demand models. Travel demand models for urban areas typically concentrate on person estimates and at an aggregate level also estimate commercial vehicle (i.e., truck) movements. To produce consistent compatible estimates of passenger and commodity/freight movements, agencies have not integrated the SAM and urban travel demand models. The purpose of this research was to provide a Texas analysis model that would disaggregate statewide estimates of commodities/freight within the Texas traditional urban travel demand model boundaries. The research has developed a disaggregation model for integrating the SAM commodity estimates into the urban framework and a “bottom-up” model for estimating the commodity movements internal to the urban area that occur in addition to statewide movements. The integration of the SAM estimates involves disaggregation of internal to internal, external to internal, and external to external movements. The SAM accomplishes disaggregation using existing demographic data at the urban level. The urban model component uses data from typical urban travel demand models, including software currently used by TxDOT in their urban travel demand models. Modeling data such as shipping/receiving rates, trip length, load factors, etc. were developed from travel surveys done as part of the state travel survey program. The urban model also specifically estimates vehicle (truck) movements that do not involve the transfer of commodities as well as movements of empty vehicles. Included in the research was the application of the urban model and integration of the SAM estimates for the Houston-Galveston Area to develop estimates of commodity movements in the Houston-Galveston Area and estimate the truck movements associated with those commodities.					
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CHAPTER 1 – INTRODUCTION

BACKGROUND

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the Transportation Equity Act for the 21st Century (TEA 21) require that states and metropolitan planning organizations (MPOs) consider urban freight in their long-range plans, transportation improvement programs and annual work elements. The movement of freight on state and local roadways has increased throughout the United States. The 2002 Commodity Flow Survey (CFS) reports that companies moved over 43 million tons of goods (i.e., freight) daily in the U.S., and freight movements in tons grew 18 percent between 1993 and 2002 (*I*). Truck is the dominant mode of transport with 58 percent of the total 15.8 billion tons of freight reported in the 2002 CFS (*I*). Freight movements by truck impact congestion, air quality, mobility and accessibility within urban areas.

Various state and local agencies throughout the country seek tools that provide current and future information on commodity and freight movements. These tools can assist transportation planners in the planning and implementation of transportation projects that support efficient movement of passengers and freight within urban areas. Economic land development patterns can impact both demand and supply of commodities and freight as well as their movement patterns, including mode and route. The planning and design of efficient transportation infrastructure is enhanced by the ability to estimate and forecast freight movement patterns within urban areas.

The Texas Department of Transportation (TxDOT) developed the Texas Statewide Analysis Model (SAM). The SAM is TxDOT's first multimodal statewide freight and passenger modeling effort. The SAM passenger and freight models were designed to use the same data and model framework as much as possible, and are based on the traditional four-step travel demand modeling concept, i.e., generation, distribution, mode split, and assignment. The objective of the freight part of the model is to provide information on freight movements to perform high-level planning analysis of national and international transportation issues as they may impact the state of Texas.

Researchers designed the SAM to estimate and forecast statewide passenger and commodity freight flows. These estimates are done at a level that is not directly compatible with the urban travel demand models utilized within urban areas of 50,000 or more population. Transportation modeling efforts within urban areas in Texas have typically concentrated on the movement of people. The movement of freight within urban areas has been estimated using very aggregate models that predict movements of trucks (or commercial vehicles). A need to link the commodity estimates in the SAM with the travel demand models within urban areas was identified to accomplish two objectives:

- improve the urban models in the area of freight and commodities; and
- insure the statewide estimates and urban area estimates of freight and commodity flows were consistent.

This research builds on the statewide model and improves TxDOT's ability to estimate and forecast freight and commodity movements within urban areas by integrating the SAM results

into the urban travel demand modeling framework and developing additional tools to predict this growing segment of travel within urban areas.

PROJECT OBJECTIVES

The objective of this research is to develop the tools and methods to integrate the SAM results into the urban area travel demand modeling framework and provide improved estimates of freight/commodity movements within urban areas. The project objective was met by developing a post-processing model of the freight movement by commodity type resulting from SAM with improved models for estimating the additional movements of freight/commodities that result from movements of freight/commodities into, out of, and through urban areas as well as the movements of freight/commodities that are generated internally in urban areas.

Researchers developed three products from this research.

- A post processor model to disaggregate the estimated zone-to-zone movements of commodities/freight by mode into zone-to-zone estimates at the urban area level. While the SAM is expected to estimate these movements for the state using a compatible zone system with the system used in urban area models, the state zone system is not as detailed as those used in urban areas.
- A commodity/freight model to estimate the additional commodity/freight movements by mode at the urban zone system level. Commodity/freight movements into and out of urban areas generate in some cases additional movements of commodities and freight to their final destination. To accurately reflect total commodity and freight movements within an urban area, it is necessary to develop the means to estimate these additional movements that are related to the state, regional, and national commodity and freight movements by mode.
- A model to estimate commodity and freight movements that are wholly generated and contained within the urban area. This is the segment of commodity/freight movements that is not estimated as part of SAM but composes a significant portion of movements within the urban area. The inclusion of this model within this research project ensures the final results are comprehensive and consistent with the urban area modeling efforts.

RESEARCH APPROACH

The challenge of modeling freight/commodity flows within urban areas is addressed as a top down and bottom up approach within the modeling structure currently used by the majority of urban areas within Texas. The top down approach deals with the integration of the SAM modeling results into the framework of the urban travel demand model for an urban area. The issues associated with this aspect are primarily how to reasonably disaggregate the SAM results and incorporate them into the framework of the urban model. The bottom up approach deals with the issues of estimating the amount of freight/commodities that are being shipped and received at the urban zone level. These estimates must reflect the distribution of freight/commodities from the SAM model (i.e., the multiplier effect) and the internally generated and distributed freight/commodities for the urban area that are not included in the SAM estimates. The lack of data and information on commodity/freight amounts and movements at the local level complicate these issues. Most freight/commodity data are collected through national surveys with the results

being representative of regional interstate and intercity movements with urban data reported in aggregate values.

The top-down and bottom-up approaches are addressed within the context of the modeling structure typically used in nearly all of the urban areas in Texas. That modeling structure is a three- and four-step process involving generation, distribution, mode split (in four-step models), and assignment. The intent of this research was to accomplish its objectives in a manner that would not establish a new modeling paradigm or process outside the procedures, etc. typically applied within urban areas. In addition, it was recognized that to the extent possible the results of this research should utilize existing data sources that are typically collected and forecast for travel demand modeling. Using existing data sources would ease the implementation of this research into the current travel demand modeling practice in Texas.

The first tasks within this research were to review the literature and ascertain the state-of-the-practice in modeling commodities/freight. This review was supplemented with a survey of Metropolitan Planning Organizations and state Departments of Transportation (DOTs). An assessment was also made of the SAM relative to current practice in statewide modeling around the country. Following these efforts, an examination of data sources was conducted to assess their applicability for use at the local level. The research then developed a conceptual approach for the model(s). The concepts were then implemented and applied to an urban area to:

- demonstrate the functionality of the model(s);
- establish the specific steps and requirements for implementing the model(s); and
- examine the results with respect to reasonableness. The final task was to summarize the overall research effort and make some recommendations for future improvements in the modeling of commodities/freight.

ORGANIZATION OF REPORT

The report is organized into six chapters, including this introduction. The chapters correspond to the major research areas.

Chapter 2 presents the results of the literature review, surveys at the state and metropolitan level, and the state of the practice of commodity/freight modeling. The chapter includes a description of key findings from the review of freight/commodity modeling efforts in the U.S. and abroad, a discussion of commodity-based and vehicle-based models, as well as extensions and modifications to the four-step model. A description of the state and MPO survey results are presented with a summary and highlights on commodity/freight model development.

Chapter 3 discusses the structure and modules of the SAM freight component. This chapter summarizes SAM's zoning structure, input parameters, trip generation, trip distribution, and assignment modules and results. A comparison of the SAM with other statewide models identified in the literature review and surveys is presented for each step of the freight/commodity modeling process.

Chapter 4 presents and discusses the conceptual structure of a proposed urban-area commodity/freight model. The different steps of the processes are presented, starting with the dis-aggregation procedure converting the SAM results at the regional level into urban area traffic

analysis zones (TAZs). The various alternative methods to perform this operation are described with the recommended process. The estimation of freight/commodities generated internally and by special generators within the urban area and the proposed process is discussed, followed by a description of the distribution and assignment methods.

In Chapter 5, the research team applies the proposed methodology to the Houston-Galveston Area (HGA). The results for each of the steps of the process are described including the procedures involved in each step.

The final chapter presents the findings of this research with recommendations for improvements in various travel surveys to provide necessary key data for the application of the urban freight model in other urban areas within the state.

CHAPTER 2 – FREIGHT/COMMODITY MODELING PRACTICE

LITERATURE REVIEW

An extensive literature search was performed on the Transportation Research Board's (TRB) Transportation Research Information Service (TRIS) database, the Federal Highway Administration (FHWA) and the National Technical Information Service (NTIS) databases. More than 200 records were analyzed and from these the most relevant papers were selected for further analysis. Key areas for selection included:

- Truck;
- Commodity;
- Goods Movement;
- Freight; and
- Travel Demand Forecasting.

The search was restricted to the research conducted primarily after 1990. However, some earlier studies have been cited only if they were deemed important for this study. For ease of discussion, the terms freight, commodity(s), and goods movements are considered synonymous. As part of the literature search, the major data sources were also reviewed. These findings were further supplemented by a survey of state Departments of Transportation and Metropolitan Planning Organizations around the nation. This chapter is organized to first discuss the two fundamental modeling approaches in the U.S. and the results of the literature review relevant to these approaches. The Freight Analysis Framework (FAF) developed by the FHWA is discussed relative to its content and information that may be used for freight modeling and planning. The next section discusses the findings of the review of international modeling experiences. A discussion of some extensions and modifications to the four-step freight model is presented followed by a brief review of some recent model developments. The results of the surveys of state Departments of Transportation and Metropolitan Planning Organizations are presented followed by a summary of the literature review.

Commodity-Based and Vehicle-Based Generation Models

Modeling freight is a requisite for meeting federal requirements to incorporate freight transportation into the continuing, comprehensive, and cooperative transportation planning process for urban areas. Freight is a more complex and challenging subject than person travel. This fact is illustrated somewhat by the diverse criteria that have been used for characterizing freight demand. These criteria include:

- weight (e.g., tons);
- vehicle (i.e., truck) trips;
- value of goods (commodities);
- units (e.g., truck loads, less than truck loads, number of items, etc.);
- and volume (e.g., cubic feet, carloads, containers, etc.).

The practice of freight modeling in the United States has generally followed the evolution of person (i.e., passenger) travel modeling techniques. The amount of research and development of modeling theory and collection of travel data and information for person (i.e., passenger) models has been more extensive than that for freight models. Elegant theoretical models like those developed by Harker and Friesz (1986) (2) have not been implemented into mainstream model development probably due to their complexity. Freight travel demand network models developed for U.S. applications typically follow the three or four-step passenger modeling process (i.e., generation, distribution, mode split, and assignment) and fall into two main categories:

- Commodity flow models or “commodity-based” (CBM); and
- “Vehicle-based” models (VBM), sometimes referred to as truck travel models.

The focus in commodity-based models is on modeling commodity flows and the units are weight or value. Commodity-based models have been applied more at the regional and/or statewide levels, and sometimes accompany a link to an economic sub-model. Table 2.1 provides a brief overview of some of the relevant U.S. models/approaches/studies reviewed and classifies them based on the type of model or methodology utilized. It is interesting to note that a number of areas have modified approaches that do not follow a sequential three- or four-step process.

The commodity-based modeling approach typically starts with a known region-to-region table of commodity flow tonnage that is determined based on economic output forecasts and regional trade patterns or obtained from surveys. The inbound and outbound flows are dis-aggregated to a zonal level based on economic data that reflects intensity of production and consumption (e.g., zonal employment levels). Flows are sometimes converted to trips once they are allocated to origins and destinations (i.e., flow tables are converted to trips) based on commodity specific payload data. Economic data and/or input-output (I/O) tables may be used to estimate the quantity of each commodity produced and consumed within each geographic unit. Knowing the commodity being shipped, it becomes possible to link producers of a commodity with consumers through these relationships. Once commodity flows are assigned to origins and destinations, they are converted to trips by mode. The key assumption in the linkage is that focus on cargoes enables these models to capture the economic mechanisms that impact freight movements, hence attempting to capture the influence of economic factors on freight demand.

Vehicle-based models have typically been applied mostly at the urban scale following the structure of the person (i.e., passenger) travel models. As Table 2.1 indicates, they have not typically been used in the development of statewide models. Commodity-based modeling is predominantly the state-of-the-practice in statewide modeling. As the name indicates, vehicle-based models focus on modeling vehicle trips. They have been described as an “approach where truck trips are generated directly, usually as a function of different land uses and trip data from trip diaries or shipper surveys” (3) (Jack Faucett Associates, 1999). The trip rates are calculated as a function of socioeconomic data (e.g., trips per employee) or land use data (e.g., trips per acre).

Almost all U.S. models/approaches reviewed have a sequential structure in that, both types of models are structured in the traditional sequential four-step process: trip generation, trip distribution, mode split, and traffic assignment steps. Trip generation involves estimating the total freight movements produced and attracted (or consumed) by each zone. Trip distribution involves the estimation of freight movement between zone pairs. The mode split step segregates

the movements by transportation mode. Trip assignment involves assigning the freight movements to the network for each mode.

Sometimes, models are observed to have all four steps and sometimes, some steps are skipped and merged in with other steps while still retaining the sequential structure. For instance, some models skip trip generation altogether and go directly to distribution. The original Wisconsin model falls into this category. Figures 2.1 and 2.2 show examples of the process for both approaches.

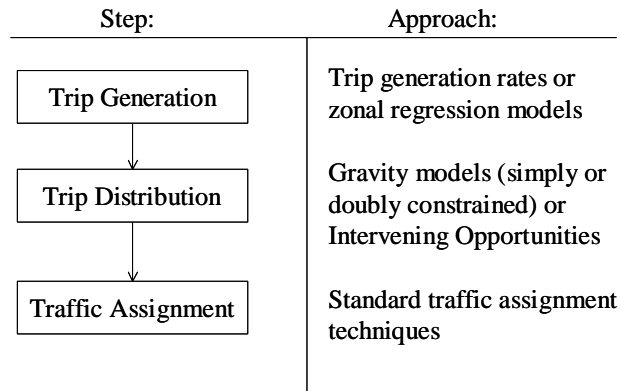


Figure 2.1. Example of Model Components of Vehicle-Based Approaches (30).

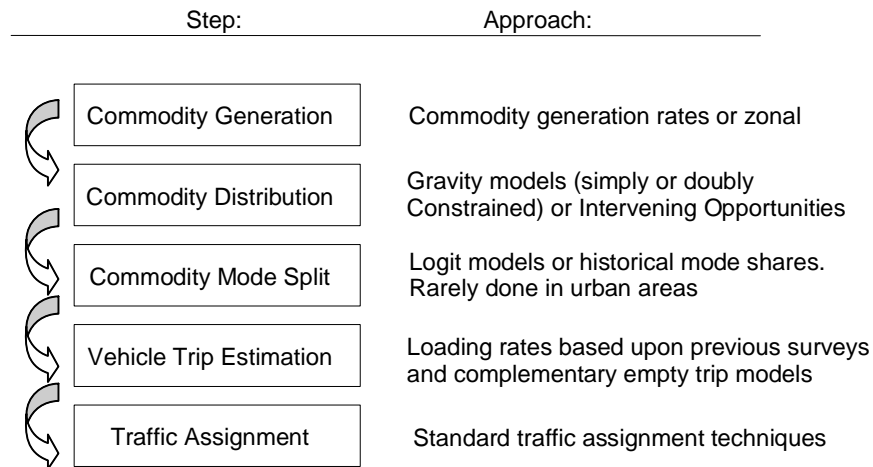


Figure 2.2. Example of Model Components of the Commodity-Based Approaches (30).

Vehicle-Based and Commodity-Based Model Comparison

This section presents a general comparison of the different steps of the commodity-based and vehicle-based modeling techniques.

Vehicle Trip/Commodity Generation

Vehicle-based models/methods use two major approaches in trip generation. These models/methods are:

- Simple rates (total truck trips generated divided by a single independent variable).
- Linear regression models (trips are estimated as a function of independent variables using standard regression procedures). When this is the case the independent variables are typically demographic variables (employment and/or population) for different land use categories and/or different truck weight classes.

Commodity-based models/methods use the following two approaches for commodity generation.

- Commodity flow models (tonnage flows of commodities from one zone to another) typically use regression methods with the tonnage of a particular commodity as the dependent variable with various demographic data, transportation system data, etc. as independent variables. Commodity flows for model development come from surveys (private and/or public).
- Input-output methods (I/O) determine production and attractions (i.e., consumption) for zones.

Some studies have also completely bypassed trip generation by generating origin-destination (O-D) matrices directly from existing data sources.

Distribution

Distribution is the process by which estimates of the amount of commodities or number of vehicle trips moving between zones are developed. Commodity-based and vehicle-based distribution is typically performed using the Gravity Model (GM). The amount of a commodity moving between two zones is a function of the amount produced (or shipped) in the origin zone, the amount consumed (or received) in the destination zone, and the resistance to travel (this resistance could be a measure of distance, travel time, or a combination of measures including travel cost) between the zone of origin and the zone of destination. For example, a constrained gravity model could produce estimates of flow between all origins and destinations with a given set of productions and attractions (or consumptions), and an average length of shipment. The outcome is constrained to meet all of the input parameters, amount produced, amount attracted/consumed, and average trip length. In lieu of the resistance measures, friction factors for the gravity model can be calibrated for a base year and used for modeling flows for a future year. If various types of commodities are analyzed, each may be modeled separately.

Mode Split/Diversion

Mode split is the process of estimating the amount of a commodity that each mode available between all pairs of zones will transport. While mode split models are primarily used in commodity-based models, they may also be adapted for use in vehicle-based models to estimate movements of different size vehicles. Modes that may be considered include trucks, rail, air, water, and pipeline. When multiple modes are considered, mode choice/split can be done using historical data or choice/probabilistic models. For example, modal split was explicitly considered

in the case of Indiana and Florida. In the case of Indiana, it was done using NEWMODE (Indiana software) which essentially relied on historical shares of modes to perform mode split. Florida's model under development considers logit models to model mode diversion. The logit models are probabilistic models, which estimate the probability of any given mode (i.e., each mode is modeled as a discrete choice) being adopted as a function of several independent variables. More details on the Florida and Indiana models are available in subsequent sections. On the other hand, Oregon's efforts incorporate a series of discrete choice models to analyze behavioral processes. In a CBM, the flows (tonnage) are allocated to various modes. After the mode split process occurs, transformation modules are sometimes applied to convert flows to vehicle trips after which the trips are assigned to the network (either individually or jointly with passengers).

Calibration

The calibration of a vehicle-based or commodity-based model is the process of adjusting input parameters to the model to make the model results match known or observed values. These variables may include:

- observed commodity flows;
- average trip times by vehicle category;
- highway commercial vehicles traffic counts; or
- estimates of vehicle miles of travel.

Forecasting

Almost all the statewide models reviewed indicated that they have forecasting ability. Currently the Kansas method utilizes trend lines and growth factors. The Indiana and Virginia studies use regression methods for forecasting. In Wisconsin, the freight forecasts were developed with econometric factors derived from long-term trends. Industrial employment and productivity were used for forecasts using the trend line logic. However, in the case of Wisconsin, one research paper used growth factors for forecasting. At least two ongoing statewide efforts that have been reviewed as part of this effort also mentioned having forecasting abilities. Florida, like Indiana and Virginia uses regressions for forecasting while Oregon utilizes simulation tools. The majority of models use freight forecasting techniques that have been documented in National Cooperative Highway Research Program (NCHRP) Report no. 260 (4) (1983).

The study conducted by Memmott was one of the earliest and most comprehensive treatments of a systematic freight analysis process (4) (Memmott, 1983). It focused on documenting the existing state-of-the-art (as of 1983) in freight demand forecasting and data requirements at the time the report was written. His report documented techniques to:

- quantify freight flows by mode for current year;
- forecast likely annual freight volumes and mode shifts over the short-term (less than 5 years); and
- provide origins and destinations by commodity within a corridor or region at substate, state or multistate levels. This data could be useful for any state in their forecasts.

Memcott's (4) freight traffic generation evolved with the development of a base case commodity O-D flow data matrix from which future flows could be predicted. Freight distribution was done using county-level employment. Forecasting the future year freight flow O-D matrix was divided into three categories:

- causal methods (regression methods, input-output methods, econometric methods, diffusion indices, leading indicators);
- time series analysis and projections; and
- qualitative methods.

In addition, this report also mentions that the Fratar growth factor method can be used in extrapolating O-D matrices for short forecast periods. Of the studies reviewed, only one study used growth factors for external stations in a 1-year back-forecast of the truck trip O-D matrix (5) (Sorratini and Smith, 2000).

Guidebook for Forecasting Freight Transportation Demand 1997 (8) (Cambridge Systematics, et al., 1997) is one of the most recently published work on freight planning. It aims at assisting planners and practitioners to integrate freight planning and demand forecasting effectively into the broader process of multimodal planning. This guidebook focuses on using economic indicator variables such as employment and population to arrive at a growth rate for estimating future commodity flows for existing facilities.

Starkie (6) performed one of the most influential and innovative studies of goods vehicle trip generation. His analysis entailed the estimation of a variety of simple, univariate regression models relating daily volume of truck trips observed at the plant to employment and floor space. These models link trip generation to type of manufacturing activity.

These studies highlight the significance of economic indicator variables (employment, employment density, tonnage produced) and commodity distribution. These are the variables that are typically used to apportion statewide commodity flows. Level of service and proximity have been used to apportion flow to the various entry-exit points of a region. These results were noted to be much more accurate when commodities were disaggregated.

This literature review indicates that many forecasting techniques as documented in Memcott's study are now the state-of-the practice in statewide and urban models.

Table 2.1 presents examples of models reported in the literature, whether the models are sequential in nature and discuss some of the specific steps that are included. Table 2.2 presents information on some of the ongoing and/or recently completed models and/or studies. Tables 2.3 and 2.4 indicate the data sources that have been used in the generation stage of both vehicle-based and commodity-based modeling. Appendix A presents a description of the most common data sources and databases used for freight modeling. Ancillary data sources used in transformation modules required for conversion of output units from flows to trips are also shown in Tables in 2.3 and 2.4. This is done by listing some example applications that actually start from flows and report either in trips (and value using value to value-to-weight ratios in some instances). Appendix A discusses in detail all the data sources. In commodity-based modeling trip generation, the output dimension is typically in tonnage flows (a weight measure).

In intermediate stages, these flows could be converted to flows in value (monetary terms) using value-to-weight ratios.

Table 2.1. Examples of Commodity-Based and Vehicle-Based Approaches in the U.S.

Application	Developer/Source	Commodity- / Vehicle-based	Comments
Quick Response Freight Manual Final Report (QRFM)	Cambridge Systematics, 1996 (8)	Vehicle-based	Trip generation is performed by applying default trip generation rates to employment categories and households. Distribution is done using the Gravity Model with friction factors based on travel time or distance. Assignment is done on the basis of “passenger car equivalence (PCE).”
Small-/Medium-Size Areas in Washington	Faris and Ismart (1999) (9)	Vehicle-based	Trip generation is done using the QRFM rates. Trips are assigned to various networks by truck type using equilibrium and all-or-nothing techniques.
Phoenix Metropolitan Area-Urban Truck Travel Model	Ruiter (1992) (10)	Vehicle-based	Maricopa Association of Governments (MAG) internal trips used truck travel diaries. Land use at trip end. Linear regression models and land use rates were estimated for each weight class.
Iowa Statewide Truck Forecasting Model	Souleyrotte, Maze, Pathak, and Smadi (1996) (11); Souleyrotte Maze, Strauss, Preissig, and Samdi (1998) (12)	Commodity-based	Does not follow the four-step typical process. Layered approach in which each commodity group is modeled separately. No trip generation or trip distribution steps. O-D matrices created in a spreadsheet using freight traffic information. Mode split is not incorporated into the analysis because truck traffic is the focus, and the data already has separated mode choice.
Michigan Statewide Truck Model	Nellet, Robinson, McKinley and Witherspoon (1996) (13)	Vehicle-based using Commodity Flows	Trip generation. Two-stage destination choice model used with region-to-region flows from 1983 benchmark input/output (I/O) accounts. Assignment: All or nothing using generalized travel cost.
Indiana Commodity Flow Model	Black, (1999) (14)	Commodity-based	Two modes rail and truck included. Trip generation: Linear regressions (employment and population as independent variables) formed the basis for forecasting commodity productions/attractions Distribution: constrained GM. Mode Split: Historical splits. Assignment: All-or-nothing.
Wisconsin, Using Commodity flow survey data to develop a truck travel demand model	Huang, Smith (1999) (15)	Commodity-based	Truck mode. No generation. 1992 CFS data provided the basis for a full O-D truck-trip table. External trips were assigned with two methods: Boundary Balancing and Global Shortest Path. The gravity model was calibrated for each trip type and for the allocation of external trips to external stations. Friction factor curves were developed and tested. Trip tables were merged and assigned to the network and link volumes were compared to actual truck volumes.

Table 2.1. Examples of Commodity and Vehicle-Based Approaches in the U.S. (Cont.).

Application	Developer/Source	Commodity- / Vehicle-based	Comments
Wisconsin, Development of a Statewide Truck Trip Forecasting Model Based on Commodity Flows and Input-Output Coefficients	Sorratini, Smith (2000) (5) Sorratini (2000) (16)	Commodity-based	1993 CFS data and Reebie TRANSEARCH database used to create commodity trip tables. Gravity model used to distribute internal and internal-external (IE) truck trips. Fratar model used to distribute external-external (EE) trips. Trip length frequency distributions developed in a previous study used for calibrating gravity model. All-or-nothing assignment technique used after merging all four trips types.
Wisconsin Statewide Model (original model)	Referenced in QRFM, (1996) (8)	Commodity-based	Reebie TRANSEARCH data supplemented with Wisconsin-specific commodity flows. No generation equations, flows are distributed at the county level based on employment and population. New models being developed for Wisconsin.
Southern California Association of Governments (SCAG) Study: Heavy-Duty Truck Model	Meyer, Mohaddes Associates, 1999 (19)	External commodity-based Internal vehicle-based	Trip rates developed for three truck classes. Forecasts based on truck trip generation rates developed through surveys, regional economic data, commodity flow data and activity at special generators. Distribution: GMs with friction factors developed from trip diary surveys.
Los Angeles Developing a Truck/Freight Model for the Los Angeles Metropolitan Area Phase 1: Building a Preliminary Model Framework using Cube Cargo	Los Angeles County Metropolitan Transportation Authority and Citilabs, 2004 (48)	Commodity-based	Generation: Regression models using zonal socioeconomic variables. Parameters and constants estimates based on observed commodity flow data. Special generators used to represent externally generated commodities. Trend rates used to represent production efficiencies and other factors not captured in regression models as well as trends in levels of imports and exports. External estimates developed from user specified values. Distribution: GMs with generalized costs for impedance. Mode Choice: Models are multinomial logit. Modes include truck, rail, and air. Assignment: Micro-simulation models.
Atlanta, Georgia Development of an Urban Commercial Vehicle Travel Model and Heavy-Duty Vehicle Emissions Model for Atlanta Region	Thornton etal. (1998) (20)	Vehicle-based	Generation: Internal truck trips estimated using cross classification of trip rates by two vehicle classes and land use/employment categories. External truck trips estimated using regression equations for two classes of vehicles developed from external survey. Distribution: GMs.

Table 2.1. Examples of Commodity and Vehicle-Based Approaches in the U.S. (Cont.).

Application	Developer/Source	Commodity / Vehicle-based	Comments
<p>FASTruck Forecasting Model for Puget Sound Region (Seattle, Washington State DOT)</p>	<p>Cambridge Systematics and Kuppam (2002) (17)</p>	<p>Hybrid</p>	<p>Use: Three-step model. Five performance metrics were established for tracking. It operates in tandem with the person travel model, sharing data when appropriate.</p> <p>Model consistent with Puget Sound Regional Council’s travel demand model for passengers (data, network). 215 forecast zones, 850 Traffic Analysis Zones (TAZs).</p> <p>Data: Reebie TRANSEARCH (1997) and 2020 forecast) data are used for preparation of external trip tables. 37 Commodity groups. Vehicle Inventory and Use Survey (VIUS) provided the payload data.</p> <p>Generation: Regressions on employment. Grouping is a function of data availability (rather than perceived homogeneity).</p> <p>Trip tables: Three classes of trucking activity for forecasting to support the model (light, medium, heavy):</p> <ul style="list-style-type: none"> -Local delivery trucks: QRFM trip rates by employment category. Distribution uses a gravity model. -Short-haul, long-haul, and through trucks: External regions aggregated to provide flows in and out of the region. Internal destinations allocated to TAZ for assignment. Allocations based on associating industry groups with employment categories. -Special generator trips: Conducted for those that could not be adequately modeled with methods used for other trucks mentioned above. Data came from various sources. <p>Vehicle Trip Estimation: Flows converted to trips using VIUS. Three trip tables are produced (Internal-External; External-Internal; External-External).</p> <p>Assignment: Trip tables converted to passenger car equivalent (PCE). Multi-class assignment. PCE factors light (1.5 vehicles), medium (2.0 vehicles), heavy (2.5 vehicles).</p> <p>Validation: Use a + - 10 percent criterion when comparing volumes to counts.</p>

Table 2.1. Examples of Commodity and Vehicle-Based Approaches in the U.S. (Cont.).

Application	Developer/Source	Commodity / Vehicle-based	Comments
New Jersey Statewide Truck Model	Referenced in Cambridge Systematics (2001) (18)	Vehicle-based	<p>Use: Sensitivity related to changes in truck travel patterns and toll facility truck volumes in response to toll changes. Explore impact of new freeway construction. Impacts of major new construction on truck volumes.</p> <p>Generation: Combination of methods used for internal-internal (II) (zonal regressions); IE; external-internal (EI); and EE. Internal zones; trips are a function of employment, households, and truck terminals. The allocation between EI and II trip ends in these zones are a trip type-specific function of accessibility terms based on number of trips at each external station divided by travel time from external to internal zone. Truck terminal attractions are based on Institute of Transportation Engineer's (ITE) rates. At external stations, truck counts were used to develop historically based growth rates to apply to future years.</p> <p>Distribution: GM. Travel cost changes (time/tolls) added.</p> <p>Assignment: Simultaneous with passenger trips using same link impedances.</p> <p>Truck only. No mode choice.</p> <p>The New Jersey model was developed to overcome the deficiencies of the commodity database from DRI/McGraw Hill used previously to obtain truck trip tables.</p>
Massachusetts Truck Model	Krishnan and Hancock (1998) (21)	Commodity-based	<p>O-D matrix created from Commodity Flow Survey, 1993.</p> <p>No generation.</p> <p>Assignment: User equilibrium.</p>
Centre county, Pennsylvania	Marker and Goulias, (1997) (22)	Vehicle-based	<p>Model based on QRFM methodology. Aim was to assess the impact of aggregation (county versus traffic analysis zones) on estimated link truck volumes.</p> <p>Trip generation, distribution and assignment steps included. Calibration with traffic counts using QRFM calibration method.</p>

Table 2.1. Examples of Commodity and Vehicle-Based Approaches in the U.S. (Cont.).

Application	Developer/Source	Commodity / Vehicle-based	Comments
Wisconsin Statewide Freight Model	Park and Smith (1997) (23)	Vehicle-based	Generation: Truck trip productions and attractions estimated at zone level using trip rates (as function of population) developed from O-D surveys. Distribution: GM with friction factors based on trip length frequency distributions from the O-D surveys. Assignment: All-or-nothing minimum time path. Selected link analysis used to adjust zonal productions and attractions through feedback in calibrating model.
Kentucky Statewide Traffic Model	Wilbur Smith Associates, (1997) (24) referenced in Holguin-Veras et al, (2001) (30)	Commodity-based	Single mode. Trip generation: Population used to disaggregate for production/attraction. Trip distribution.
Kansas Statewide Model	Russell, Sorenson, and Miller, 1992. (49)	Commodity-based	Commodity flow data developed for five commodities based on O-D data collected at external stations and locations within the state supplemented by surveys. Data collected for three modes. Commodity movement tables created for II, EE, and IE movements. Commodity flow tables converted to truck flows based on assumed loadings per truck. Movements assigned to networks using all or nothing assignment.
Statewide Freight Trip Forecasting Model for Nebraska	Jones and Sharma (2003) (26)	Commodity-based	Data from 1993 Commodity Flow Survey, census of agriculture, Nebraska Databook, and the 1992 U.S. Economic Census used to develop annual tonnages of commodities produced and hauled by trucks. These production estimates were disaggregated to the county and traffic analysis zone levels using employment and population data. Data from a Wisconsin study were used to convert the tonnages to truck trip productions based on average tons per truck trip by commodity. Freight attractions were estimated using an input-output approach and the IMPLAN software that contains a 1992 database. A separate generation model was developed for agricultural trip productions and attractions. Methods of distribution and assignment were not discussed in the paper.

Table 2.2. Ongoing Studies in Statewide and Urban Area Freight Modeling.

Application	Developer/Source	Commodity / Vehicle-based	Comments
Destination, Mode and Routing Choice Models for Freight	Jack Faucett Associates (1999a, 1999b) (3)	Combination	Began 1998. This research is focusing on development of forecasting tools for state DOTs and MPOs. Some early recommendations are: Commodity-based model for goods movement (heavy commercial vehicles) with I/O model, and vehicle-based for non-goods movement (light vehicles).
NCHRP Project 8-43 Methods for Forecasting Statewide Freight Movements and Related Performance Measures	Cambridge Systematics (27)	Not known	Began 2002. Slated for completion in mid-2004. Main objective of this study is to provide a framework for forecasting at the statewide level. It will include, among other aspects, a toolkit of data collection techniques, analytical procedures, and computer models. Literature review conducted.
Statewide Inter-modal Freight Planning Methodology: Virginia DOT	Brogan, Brich and Demetsky (2001) (28); Eatough, Brich, Demetsky (1999) (29)	Commodity-based	Trip generation: Linear regressions formed the basis for forecasting (employment and population variables). These varied by commodity type. Attractions/productions: This will be a key input into Virginia Statewide Model Developments, which are being done by Wilbur Smith Associates. See web documents: www.wibursmith.com/vdotmodel/ .
An Assessment of Methodological Alternatives for a Regional Freight Model in the NYMTC Region	José Holguín-Veras etal. (2001) (30)	Commodity-based	One of the MPO level studies that employs commodity-based techniques. Framework finalized. A multi-regional I/O model is proposed for trip generation part. Other details are unavailable at this time.

Table 2.2. Ongoing Studies in Statewide and Urban Area Freight Modeling (Cont.).

Application	Developer/Source	Commodity / Vehicle-based	Comments
Florida DOT -Florida Statewide Intermodal Highway Freight Model or Freight Truck Travel Demand Model	Cambridge Systematics (31)	Commodity- based sequential	Focus of statewide model is on long-distance freight only, not on service trucks or local delivery trucks. Integration with Urban area models: The statewide model was envisaged to provide input to regional and urban area models and trip tables for those trips with one end outside of an urban area model as EI flows. Interface at external stations only makes it compatible with different urban area efforts. This has not happened yet because of database issues. Trip generation: Linear regressions of TRANSEARCH data, population and Standard Industry Code (SIC) employment. Forms the basis for forecasting. Aggregation: County level because generation equations depend on variables that are mostly available at county level. This relation will be applied at TAZ level during validation stage. Trip distribution and mode split: County-to-county skim matrices for travel times. Gravity model. Mode split: Existing mode split as in TRANSEARCH. Mode choice: Incremental Logit models based on stated preference surveys. Logit equation is applied to change in utilities resulting from changes in cost or time to estimate a percentage change to apply to base mode share. Assignment: All-or-nothing. Status: Operational. See web sites: www2.myflorida.com/planning/systems/stm/mtf/01docs/fr_min3.pdf webservices.camsys.com/freightmodel/scope.pdf
Oregon DOT	Donnelly R., PB Consult, 2002 (32) Hunt, J.D., et al. University of Calgary 2001 (33)	Commodity- based for regional/national Vehicle-based for local and internal trips. Hybrid model Integrated- transportation land use model	Oregon is currently developing its second-generation statewide model. A combined input-output/econometric model is used for trade flow forecasting. There are seven connected modules. Several modules involve micro-simulation. Zones: The commercial components have the same spatial unit as land use models: parcels (not TAZ).

Table 2.3. Data Used in Vehicle-Based Models.¹

Study	Land Uses	Truck Weight Classes	Dependent Variable	Comments/Data Sources
Truck Travel Model for Phoenix Area, Ruitter, 1992 (10)	Office, Retail , Industrial, Government, Households, Other Businesses	0-8000 lb. 8001-28,000 lb. 28,001-64,000 lb. > 64,000 lb.	Employment Households	Trip rates (household trip rates are trips per household and all other trips are trips per employee) by TAZ. Trips rates are for one end internal to region. Data are collected from trip diaries.
Freight Modeling, Faris and Ismart (1999) (9)	No	Four-tire Single unit Combination trucks	Employment in five SICs for II commercial trips	Quick response techniques. Valid only for small- and medium-sized areas. Trips rates by TAZ.
Development of an Urban Commercial Vehicle Travel (Atlanta Region) Thornton et al. (1998) (20)	Office, Retail , Industrial, Population	0-8000 lb. (light) > 8001 lb. (heavy)	Employment Population	Trip diaries as in Phoenix study.
Development of a Statewide Truck Travel Model with Limited Origin and Destination Survey- Wisconsin, Park and Smith, 1997 (23)	No	Not Specified	Zonal Population	Rates calculated for trip attractions and productions. Based on simple trip- rate trip-generation model for three trip types. Internal and external trip rates examined O-D survey data used for calibrating gravity models. Truck classification count data were used for checking accuracy of calibrated model.
Southern California Association of Governments (19)	Households/Agriculture/Mining/ Construction Retail trade, Wholesale trade, Government, Manufacturing, Transportation, Services	8500-14,000 lb. (Light-heavy) 14,000-33,000 lb. (Medium heavy) > 33,000 lb. (Heavy-heavy)	Households Employment	Data are collected from shipper surveys to develop trips rates. (Trips per household for households and trips per employee for all other trips.) These rates combined with rates from other counties to cover other land uses.
Truck Traffic Prediction Using QRFM Using Different Degrees of Geographic Resolution, Marker and Goulias, 1997 (22)	Business Households	Four-tire Single unit Combination trucks	Employment in five SICs	Trip generation rates calculated for trip attractions and productions by TAZ using QRFM generation rates by SIC and for households.

¹ See Appendix A for description of data sources.

Table 2.4. Data Used in Commodity-Based Models.²

Study	Conversion of Tonnage to Trips	Zonal Allocation of Trips	Data Source(s) for Commodity Flows/(Public or Private Source)	Comments/Approach/Other Data/Purpose
Massachusetts Truck Model, Krishnan and Hancock, 1998 (21)	By truck category using locally collected data on commodity density, average payloads, and average percent empty trucks by truck type from Highway Performance Monitoring System (HPMS). These data are used to convert flows to trips.	Massachusetts flows allocated to five-digit zip code level using employment shares	1993 CFS	Commodities aggregated to a single category when estimating total truck tonnage flows. However, it is not a true CBM because no generation is involved because it is origin-destination based. It just takes flow data and creates an O/D matrix.
Statewide Truck Trip Forecasting Model Based on Commodity Flows and Input-Output Coefficients, Sorratini and Smith, 2000 (5); Sorratini, 2000 (16)	Average truck payload data from Reebie Associates Transearch Database (35)	Wisconsin flows allocated to counties using employment share by producing sectors for trip production. This is taken to TAZ level. For trip attractions, population is used.	1997 CFS Reebie Associates Transearch Database HPMS	Payloads and average percent empty by truck type from Highway Performance Monitoring System. Commodity flow data and I/O models used to develop production and attraction trip generation Other data: County Business Patterns (Employment)
Indiana Commodity Flow Model, Black, 1997 (34)	Annual volume flows were reduced to daily traffic using Highway Capacity Manual (HCM) conversion factors	Flows allocated to counties.	1997 Census of Transportation, 1993, CFS	Commodity flow data and I/O models used to develop production and attraction trip generation regression models using employment in the appropriate industry sector as the independent variable. Payloads and average percent empty by truck type from HPMS. Other data: County Business Patterns; Carload Waybill Sample
Multimodal Freight Forecasts for Wisconsin, 1996 (35)	Assumes a 24-ton maximum cargo weight and percent full based on percent full of carload rail shipments from the Carload Waybill Sample.	State-to-state flows are disaggregated to Bureau of Economic Analysis (BEA) regions using employment shares.	Reebie Associates Transearch Database	Relies on input-output tables.
Using Commodity flow Survey Data to Develop a Truck Travel Demand Model, Huang and Smith, 1999 (15)	Shipment weight converted to truck-trips using average weight per truck for each SIC	The statewide travel-demand model included 624 in-state TAZs and 50 external stations on Wisconsin's border.	1993 CFS	No generation is involved because it is O-D based.

² See Appendix A for description of data sources.

Table 2.4. Data Used in Commodity-Based Models (Cont.).

Study	Conversion of Tonnage to Trips	Zonal Allocation of Trips	Data Source(s) for Commodity Flows/(Public or Private Source)	Comments/Approach/Other Data/Purpose
Statewide Intermodal Freight Planning Methodology: Virginia DOT, Brogan, et al (2001) (28)	No	Flows allocated to counties within Virginia	Commodity Flow Survey used only for final accuracy checks Reebie Associates Transearch Database, 1998	Socioeconomic data for Trip generation equations. Population: Census population estimates, 1998. Employment: IMPLAN Groups' proprietary county level employment data Several other data were also used as defined by the variables in the trip generation equations.
Iowa Statewide Truck Forecasting Model, Maze, Smadi, and Souleyrotte (1996) (36)	Not Specified	Flows allocated to counties	Iowa Truck Weight Survey, Commodity Transportation Survey, Annual Survey of Manufacturers, National Cooperative Highway Research Program Data	Two modes used (truck and rail) and only two industrial sectors.
A Freight Planning Typology, Soulyrotte (1998) (12)	No conversion, output is defined in tons/year.	Flows allocated to TAZ within Iowa.	Reebie Associates Transearch Database	No generation is involved because it is origin-destination based.
Freight Transportation Planning: Converting Commodity Volumes to Vehicles, Hancock, Karthikeyan, and Sreekanth, 2000 (37)	Determination of payload matrix using neural networks.	Not Identified	1993 CFS Truck Use and Inventory Survey (TUIS)	No generation. O/D based. Mention its importance for local planning and not regional freight movements.
Statewide Freight Trip Forecasting Model for Nebraska, Jones and Sharma, 2003 (26)	No conversion	Standard Industrial Classification (SIC) employment used to allocate truck tons produced to county level. Since TAZ are zip codes in Nebraska, annual truck tons produced in each TAZ.	1993 CFS	Census of Population, Economic Census, Census of Agriculture Attractions based on input-output approach using IMPLAN.

Advantages of Commodity-Based Models

- CBMs have the potential to capture the fundamental economic mechanisms that drive freight movement, determined by freight attributes (shape, specific weight, volume) measured in tons or any comparable unit of weight. In fact, forecasts of flows are built on economic relationships between producers and consumers. They are well suited for representing movements across manufacturers and for characterizing external trips.
- The CBM can generate movements irrespective of mode. These movements can then be used in conjunction with other sub-models for the mode choice process. Hence, they are more easily adapted to multimodal analysis.

Disadvantages of Commodity-Based Models

- Since they focus on large-scale movements between producer/consumer relations, CBM automatically ignore secondary movements like multi-channel distribution moves and transshipment between moves. However, this is likely to be more of an issue when applying such approaches at the local level rather than regional level.
- Inability to capture empty trips. This is the direct consequence of logistical decisions that remain unexplained by this approach. This disadvantage could be overcome by adopting an approach suggested by Holguin-Veras and Thorson (2002) (7). It involves introducing complementary models to depict empty trips as a function of routing choices that the vehicle operators make, which are based on the commodity flows in the study area.

Advantages of Vehicle-Based Models

- The focus of the vehicle-based model is on a unit (usually truck) for which there is a significant amount of data from traffic counts, screen counts, etc.
- Intelligent transportation system (ITS) applications are able to track the movement of vehicles through the parts of the highway network, becoming an important source of traffic data
- Focusing on vehicle-trips, empty trips do not present a major problem in terms of number of units that traverse a given route.

Disadvantages of Vehicle-Based Models

- Applicability of vehicle-based models to multiple freight transportation modes is questionable because the choice process is observed by focusing on the trip itself.
- Difficult to identify and determine economic and behavioral mechanisms of freight demand

Table 2.5 presents a summary of the model comparison.

Table 2.5. Comparison of Commodity-Based Model and Vehicle-Based-Model Approaches.

Model / Approach	Features				
	Mode Choice	Short Distance Trips	Economic Influence	Empty Trips	Data Requirements
Commodity-Based Models	Yes	No	Yes	Not implicitly	Require more data than VBM
Vehicle Based Models	No	Yes	No	Yes	Truck generation rates, demographic data

Federal Highway Administration’s Freight Analysis Framework

The Freight Analysis Framework (FAF) developed by the FHWA is the policy and systems analysis prototype national commodity flow model tool developed to support a Freight Productivity Program to understand freight demands, assess implications for the surface transportation system, and develop policy and program initiatives to improve freight efficiency. The information presented in this section was taken from the Federal Highway Administration’s website (50).

The FAF examines transportation for four key intermodal modes: highway, railroad, water, and air. Its key objective was to use existing data sources. Data from several sources were assembled to provide a complete picture of freight flows by mode and commodity. Forecasts of flows by origin, destination, and commodity were also generated for 2020. A comprehensive database for different modes was developed from various government and private sector databases (Table 2.6). To evaluate the effect of anticipated volumes upon the network, the FAF includes economic forecasts for the years 2010 and 2020, assigned to the network and linked to transportation infrastructure databases. The FAF also has a highway capacity network analysis tool.

The *Commodity Flow Database* contains information on estimated commodity flows on a state-to-state basis by mode for 1998, 2010, and 2020. Based upon the HPMS database, the *Highway Capacity Dataset* contains segment level data on system capacity and truck volumes for 1998, 2010, and 2020.

FAF has developed freight maps for the state of Texas that include three truck maps for domestic only transportation, international tariff and a combined international and domestic summary. International traffic includes cargos moving to or from other gateways such as border crossing or ports. Specifically these include:

- Brownsville Border Crossing Map;
- El Paso Border Crossing Map;

- Laredo Border Crossing Map;
- Other Texas Border Crossings Map; and
- Houston, and Southern Texas Ports.

The rail maps include total rail activity for the state, and a waterways map with local flows. Table 2.6 shows the data sources used in FAF.

Table 2.6. Data Sources Used in the Freight Analysis Framework.

<ul style="list-style-type: none"> o Bureau of Transportation Statistics (BTS)/Census Bureau Commodity Flow Survey (All Modes) o BTS Transborder Freight Statistics (Truck, Rail, Pipeline) o Rail Waybill Sample (Rail) o MarAd and U.S. Army Corps data (Water) o BTS/Federal Aviation Authority (FAA) (Airport) o Reebie (Truck) o Census Bureau Five-year Census and Annual Survey of Manufacturers (Truck, Water, Air)Private Port Directories (Water) o DRI Industrial Production Indices (Truck, water, air) o WEFA Long-Term and Regional Economic Forecasts o WEFA International Trade Forecasts o Trade Association Production & Shipment Reports (Truck, Water, Air) o United States Geological Survey (USGS) Mineral Industry Reports (Truck, Water) o Reebie Associates Freight Locator/InfoUSA Street-Address Industrial Employment & Activity (Truck) o County Population Data (Truck) o Inter-Industry Trade Patterns (Input/Output Table) (Truck, Air) o Motor Carrier Industry Financial & Operating Statistics (Truck) o Railroad Industry Proprietary Rebill Factors (Truck)

International Modeling Experiences

This section presents a summary of different approaches that have been developed in Europe and Canada. Three European experiences and two Canadian applications are discussed.

Boerkamps, Van-Binsbergen, and Bovy (2000) (38) describe a framework that consists of markets, actors, and supply chain elements of urban freight movement. The research outlines the “Good Trip” model that was derived from this framework and shows the results of the application of the model in the city of Groningen in the Netherlands. The “Good Trip” model is positioned in between the aggregated four-step models and the disaggregated logistics models. The model is a demand-driven, commodity-based freight movement model that incorporates supply chains. It is structured to handle different logistics patterns as long as decisions that make up the patterns can be described mathematically. The model was used to compare the logistical performance and external impacts of three types of distribution systems: the traditional system, urban distribution system with vans, and urban underground logistics systems. The results show

considerable differences in the performance and effects of alternatives especially when applied to different types of distribution channels, such as food retail stores or bookstores.

Jourquin and Beuthe (1996) (39) developed a “Virtual Network of Freight Transportation in Europe.” The main objective of this network model was to predict choices of modes, means and routes which would result from minimization of the total transportation cost, for a given transportation task defined by an origin-destination matrix. Transport flows in the European Union were used as demand input in a network consisting of twelve European Union countries, with road, rail and inland waterway networks. Jourquin and Beuthe created the virtual network to represent loading, moving, unloading, transshipments, etc. (39).

Both of the above models appear to be short term freight logistics models and have been used for operational purposes to optimize daily routing and scheduling, and not for long-range planning.

Oppenheim (1993) (40) developed a combined equilibrium model of urban personal travel and goods movements. The author proposes combining urban personal travel and commodity flows in one single model, assuming that commodity flows are generated by the need to support a given, generic urban activity.

Ashtakala and Murthy (1993) (41) describe a model used for predicting commodity flows in Alberta. Their objective was to “determine the demand for commodity transportation using a conventional four-step sequential modeling approach.” Links connected nodes representing population centers. These centers were determined to be either producers or consumers. The model was multimodal including rail and trucks, and included multiple commodities. An extensive commodity flow survey conducted by Alberta Transportation was used in model development. The O-D flows in the commodity flow survey were at the population center level of detail. Trip generation was essentially done by the flow survey. An optimized gravity model developed in another paper was used for trip distribution. An optimized production-constrained gravity model was developed for each of the 17 commodity classes analyzed in this model. This is perhaps the only paper noted that used discrete choice logit models for analyzing mode split within the context of the four-step model. There was no assignment since there was no explicit network incorporated in the model. Calibration was conducted using commodity line-haul diagrams, which represent the length of distribution of haul for each commodity and results of survey. It was used primarily to analyze intercity flows.

Chapleau (1995) (42) discusses a “totally disaggregate approach” to modeling which is a synthesis of several works and papers and summarizes essential elements of the methodological approach to integrated transportation of goods and hazardous materials. The “totally disaggregate approach” involves information processing of individual trip data with location reference of generation and attraction of goods movement. Essentially, this involves modeling of individual good movements by location using geographic information systems (GIS) to support strategic consideration of these movements in Greater Montreal. The paper also discusses the software tools (MAD (Strat2) and MAGDAT) that were developed to handle this type of framework. A comprehensive and structured analysis architecture was developed for important interacting entities of urban goods movement system and a special GIS was adapted to the hierarchy of the urban goods movement network. The motivation of this paper and work reported in it is the inability of 4-step methods to handle movements adequately because of its aggregate nature.

In summary, international experiences seem to fall into three categories: a) those that are logistics related; b) those that address the problems of the traditional four-step approaches; and c) those that seem to be roughly similar in application to U.S. models. Boerkamps et al. (2000) (38) fall into the first two categories.

Extensions and Modifications to the Four-Step Freight Model

Modifications to Trip Generation: Use of Mutli-Regional Input/Output (MRIO) Models

Holguin-Veras and Thorson(2002) (43) is employing multi-regional input/output (MRIO) models in the case of New York Metropolitan Transportation Commission (MTC). The MRIO attempts to describe the inter-linkages among economic sectors of a geographic region subdividing the region into smaller sub-regions, each having its own I/O table. Such models are becoming part of the state of the practice in the U.S. and have long been part of the European efforts. Models such as SAMGODS (Sweden), SMILE, and REM developed for European and other countries have incorporated MRIO models as part of their national models.

Spatial Aspects of Origin/Destination Matrices

Hancock et al. (2000) (37) and Chapleau (1995) (42) have demonstrated that origin/destination matrices can be assigned coordinates in order to track movements. It is not clear that these approaches have become part of the state of the practice with respect to freight demand. Hancock applies this to the Massachusetts model, but this model does not take the steps any further than matrix creation.

Incorporation of Logistics Aspects and/or Supply Chains

Boerkamps et al. (2000) (38) integrate supply chains in a CBM model; however, this model was not used for longer-term planning considerations. Logistics costs have been applied in theoretical models of mode choice and can be addressed even in existing models if disaggregate data are available.

Recent Model Developments

Micro-Simulation of Freight Components

Some authors have questioned the validity of the four-step sequential process that is integral to all of the aforementioned studies/models (Chapleau, 1995) (42). These developments suggest that adaptations of the four-step model for freight forecasting fall short for several reasons, and have not been successfully implemented for urban goods movement. The four-step process assumes that most of the factors influencing travel choices are under the control of the driver, whereas in freight modeling there are at least four groups of actors that influence the way freight is moved: shippers, carriers, receivers and regulators. It is suggested that attempting to model the different decision-making processes in a single aggregate treatment often results in a poor approximation of each step. Other dynamics that the four-step process misses include the transshipment process that is common in freight movements, and the multiple-stop freight delivery system that trucks in the urban environment use.

Just like the advent of micro-simulation models to address passenger modeling in response to the inadequacies of the four-step model, micro-simulation of freight flows is now being considered as necessary in order to account for improved dynamics of the shipment process, improved behavioral processes. Neffendorf et al. (2001) (44) and Donnelly (2003) (32) suggest a micro-simulation of flows. A prototype model has been developed for the Portland region with an upper-level model producing zonal flows in monetary terms from a spatial I/O model and a lower-level model that estimates urban vehicle trip patterns starting from the outputs of the upper-level model (32). The lower-level model is a micro-simulation model and is a tour-/trip-based level model for freight transport by truck. This includes:

- shipment conversion from flows to value and to trips;
- allocation to individual organization;
- allocation to carrier type and vehicle type; and
- assignment of trans-shipment points.

Most of these steps are carried out via Monte Carlo simulations but observed distributions are also used whenever possible. Neffendorf et al. (2001) (44) also notes that similar models have been proposed for London with upper level based on I/O models and a lower level consisting of simulation methods.

Donnelly (2003) (32) also notes that the hybrid micro-simulation model of freight flows has been developed and is being implemented as part of Oregon's DOT Transportation and Land Use Model Integration Program (TLUMIP) in the second-generation model development effort. The first generation effort used a spatially disaggregate input-output model and estimated truck vehicle-based on estimates of monetary trade flows between each of 12 economic sectors and 122 zones.

In this case, freight modeling has been examined explicitly within the context of an integrated transportation-land use model (Hunt et al., 2001) (33). This type of an integrated model has been advocated by these authors for statewide and even sub-state efforts and freight has been explicitly introduced into this integrated model as an individual component. Integrated models are consistent models of activity choice and location rather than linked models of transportation and land use as is typical in most transportation agencies and can be used to simulate the interaction of the land-use system and the transport system. For instance, in a traditional land use – transport model, the travel demand model interacts with land-use models to produce land-use forecasts. The implicit assumption is that land use is exogenous, but integrated models consider land use as endogenously determined. Generally, this interaction is simulated by means of feedback mechanisms and integrated models make an explicit treatment of these feedback loops. One example of these integrated models is TRANUS (Barra, 1989) (45).

Structure of Oregon's Statewide (Second Generation) Model

The TLUMIP modeling framework adopted by Oregon as part of its integrated model consists of seven independent sub-modules. Figure 2.3 shows these sub-models. Donnelly's method is a multi-agent micro-simulation couched within the commercial travel model (CT) component that works to produce discrete shipments from aggregate intersectoral flows generated by the production allocation component (PI).

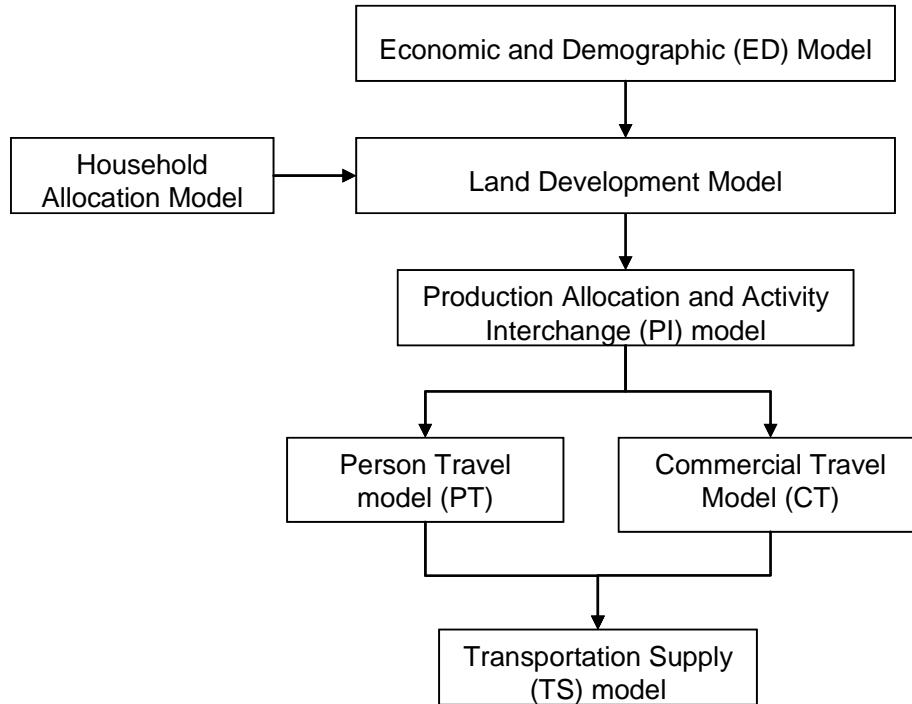


Figure 2.3. TLUMIP Modeling Framework (32).

While this approach may have several advantages, especially in regard to behavioral processes, shipper-carrier relations and federal legislations and initiatives supporting them (Clean Air Act Amendment-1990, ISTEA-1997, TEA-21 (1997), Travel Model Improvement Program- (TMIP) 1992), Donnelly’s approach with integrated models does have some limitations/assumptions.

- It has tremendous data requirements that far exceed the requirements of traditional methods. GIS data requirements are high. Donnelly (2002) (32) notes that the current implementation of the microsimulation component is beset with data problems. It is noted that there are several federal initiatives like the American Freight Survey (successor to CFS) and changes to the Vehicle Inventory and Use Survey (VIUS). These improvements are not likely to be forthcoming anytime soon. However, it must be noted that the model itself was run with scarce behavioral data and aggregate data like the 1997 CFS and it was noted that the model showed a lot of promise.
- It involves a great deal of abstraction.
- It is difficult to calibrate.

Freight Flow Data

Almost all the studies reviewed use data from the CFS or Reebie Transearch Database to estimate truck trip tables. Ambite, Guliano, Gordon et.al (2003) (46) question the reliance on secondary flow sources and suggest a bottom-up type approach to generation of commodity flows. Their method was originally proposed by Gordon and Pan (2001) (47). They criticize the current state-of-the-practice attempts to utilize existing flow databases to estimate total flows. According to the authors the existing approach is complicated by lack of detailed network flow

data (by mode) and lack an easy way to validate commercially available commodity flow data. As an alternative, a method is suggested that relies on small area employment data and a regional I/O model for generating intra-regional commodity flows (47). The technical coefficients of the IMPLAN I/O model combined with the employment data (Leontief and sales coefficients) to generate trips produced and attracted by major commodity group for each TAZ. The O-D matrix of flows (in passenger car equivalents) was developed using GIS techniques and then assigned to the network. In summary, this approach develops a methodology for estimating detailed commodity flows based on secondary data. These flows are done for all models and then truck flows are estimated for the Southern California Association of Governments (SCAG) region and distributed using gravity models. The data used in this study come from these major sources:

- Census Transportation Planning Package (CTPP S1-1)- employment data by census tract by place of work for major industrial sectors; and
- CTPP S1-2 and S1-3, which provide spatial descriptions of census tracts and SCAG TAZ's respectively.

The approach suggested by Ambite et al. (2003) (46) questioned the statistical reliability of secondary flow databases like CFS and relies heavily on the availability of other secondary data and in this application, particularly secondary employment data at disaggregate levels to produce flow estimates. It appears to hold the most potential for urban area applications.

STATE AND METROPOLITAN PLANNING ORGANIZATION SURVEY

To gather information about freight transportation planning at the state and urban area level, a survey of state DOTs and selected MPOs was performed in 2002. The survey was conducted by both email and telephone. MPOs and state DOTs were contacted to obtain information on their status in freight modeling and details on their modeling efforts.

The generic questionnaire that was used in the survey first determined if the state or MPO had developed a freight model (or was in the process of developing a model) and, if they had a model, the following questions were asked:

1. What data were used to develop the model?
2. Does the model use a network and zonal system? If yes, how many zones and types of networks are in the model? Are these zones and networks the same as used for urban transportation planning?
3. What types of commodities/freight are estimated in the model?
4. What modes are included in the model? e.g., truck, rail, ship, pipeline.
5. How does the model work? i.e., How is the amount of goods/freight/commodities produced by their model estimated at the zone level? How is the amount attracted to a zone estimated? Is it an input/output type model and how are the factors estimated?
Is it based on observed flows from existing data and, if so, how are these flows adjusted to estimate future amounts?
Is a trend line model used?
Is it a regression model and, if so, what are the dependent and independent variables used in the model?

6. What does the model predict? (Tons of commodities/freight by mode? Number of trucks by size and route? Number of rail cars by size and route? Number of ships by size and route?)
7. What type of model is used to predict the origin/destination movements? i.e., gravity model, observed trip table, logit type model, destination choice model?
8. Is model used for forecasting? If yes, what data are input to the model?
9. How are the model results interfaced with the modeling in urban areas?
10. Do urban areas incorporate the state model results in their urban area models?

The following sections summarize the results of the surveys.

MPO Survey Results

Table 2.7 presents MPO survey results. From the eleven MPOs that were contacted, eight responded, out of which seven indicated using some type of freight travel demand model. Six of the seven that use a freight model have a truck model component within the passenger travel demand models. Only Portland reported working on a commodity/truck model. San Francisco reported that it was reluctant to develop a commodity-based model due to the lack of information at the local level. This comment is consistent with the results of a survey conducted by the Association of Metropolitan Planning Organizations (AMPO) survey that concludes that data were cited by 80 percent of the respondents as the most commonly needed resource.

Table 2.7. MPO Survey Results.

Major City	MPO Name	Responded	Future plans for modeling freight/commodity
Portland	Metro	Yes	Currently working with commodity/truck freight model
Sacramento	Sacramento Area Council of Governments (SACOG)	Yes	Travel demand model with truck component. Next-generation model will be an integrated land-use transportation model.
Denver	Denver Regional Council of Governments (DRCOG)	Yes	Travel demand model with truck component
San Francisco	Metropolitan Transportation Commission	Yes	Travel demand model with truck component. Reluctant to get into commodity flow modeling due to the absolute lack of data at the local level.
Albuquerque	Middle Rio Grande Council of Governments (MRGCOG)	Yes	Travel demand model with truck component
Miami	Miami-Dade Metropolitan Planning Organization	Yes	Travel demand model with truck component
Atlanta	Atlanta Regional Commission (ARC)	Yes	Travel demand model with truck component
Nashville	Nashville Area Metropolitan Planning Organization	Yes	No model being used
New Orleans	Regional Planning Commission	No	
Boston	Boston Metropolitan Planning Commission	No	
Tampa Bay	Hillsborough County Metropolitan Planning Organization	No	

Note: Some details of the individual models were included in the literature review section.

State Survey Results

At the state level, 22 DOTs were contacted to obtain information about their freight modeling capabilities. Table 2.8 presents the results, 12 states that have a statewide freight transportation model responded. Several of the states that responded negatively to the statewide travel demand model mentioned that freight transportation-related analyses have been conducted largely at the corridor level or site-specific level, and currently those states do not have a statewide freight model. For example, Minnesota recently conducted flow studies that have elements of freight modeling. The Minnesota DOT has also been in the development stages of a Freight Commodity and Facilities Database that is intended to provide baseline information for freight movement analysis for the state.

Three other states and Texas have developed a typical four-step process freight model, while four states (Louisiana, Maine, Wisconsin, and Virginia) have a less sophisticated version of the four-step process. These models do not use generation equations to produce trip tables. Oregon and Ohio have an integrated land use transportation model. Vermont and New Jersey have developed a vehicle-based model for trucks.

Table 2.8. State Freight Model Survey Results.

State	Comments
Colorado	No freight model, possible study in the future specifically looking at the eastern part of the state
Florida	Four-step freight statewide model focusing on long-distance trucks moving on the Florida Interstate Highway System
Indiana	Four-step commodity flow model, truck and rail modes
Iowa	No statewide freight model, some MPOs have a freight component in their models. University research on specific commodities.
Louisiana	Statewide travel demand model that includes truck component
Maine	Statewide travel demand model with truck purpose component
Maryland	Does not perform freight modeling as a state function; freight is primarily addressed at project planning level. Some MPOs are developing truck surveys.
Massachusetts	Statewide travel demand model does not specifically look at trucks or freight, Boston's MPO model may include freight components
Michigan	Four-step, two-tiered model that predicts annual tons of commodities and annual trucks
Minnesota	Does not have a specific freight modeling protocol. Two freight flows studies that have elements of freight modeling have been performed recently
Nevada	No model looking at freight movements; there is interest in incorporating more freight components in model but no real effort planned.
New Jersey	Aggregation of MPO models into a statewide model that assigns trucks to highway network
New Mexico	No freight model; there were some efforts developing a synthetic truck O/D matrix in early 90's
Ohio	Under development integrated land use – transportation model that includes commercial and personal travel
Oregon	Under development integrated land use – transportation model that includes commercial and personal travel
Pennsylvania	No freight model
Texas	Four-step process multimodal model. Passenger and freight models designed to use similar data and framework.
Vermont	Four-step truck model
Virginia	Statewide multimodal transportation demand model with a goods movement component
Washington	No near-term plans to develop a state freight model. The state has a freight implementation plan which identifies role of freight
West Virginia	No statewide freight model and no plans of developing one soon. Some commodity-based research studies have been done
Wisconsin	Multimode (Truck / Rail / Water / Air), input - output model.

SUMMARY AND HIGHLIGHTS

- Most U.S. state-of-the-practice statewide models tend to be sequential 4-step and commodity-based.
- Most urban area applications in U.S. tend to be sequential and vehicle-based.
- A total of at least of seven studies were identified that employed vehicle-based techniques. These techniques were mostly regional in application. The Phoenix-Metro Urban Truck Model is an example of a vehicle-based regional model. New Jersey Statewide model is an example of a statewide vehicle-based model. Zonal unit is typically TAZ. These techniques produce trip tables by zone and by O-D.
- A total of 11-12 models/studies were found which were commodity-based. Examples include the Michigan Statewide Truck Model and Indiana Commodity Flow Model. Portland Metro is a regional application.
- Commodity-based approaches are now being applied to urban areas. An example using this kind of approach is the model being developed by the New York Metropolitan Transportation Commission.
- Commodity-based models can produce weekday freight volumes on major freight flow facilities in the region and annual tonnage of commodities produced/consumed by mode, by zone (typically county), and by origin/destination.
- Vehicle-based models do not provide a policy sensitive tool because they implicitly ignore differences in growth rates of commodities and do not provide a link to the economic environment.
- Some models are hybrid models, in that they have some components that are vehicle-based and others that are commodity-based. SCAG Heavy Duty Truck Model is an example that applies vehicle-based methods for internal trips and commodity based-approaches for external trips. The Oregon model is actually a hybrid model.
- CBM and VBM approaches have their pros and cons and decisions to adopt either approach should be based on criteria such as data availability and the need to consider multiple modes.
- Many studies are currently ongoing in the U.S. Most of these studies are not likely to be completed within the time frame of this project. The only exception is the NCHRP 8-43 study which ended in 2004.
- The FHWA-FAF has developed flow matrices that may be useful for commodity generation.
- Several theoretical extensions to four-step models have been observed (e.g., logistics, supply chains, spatial aspects, choice process); however, very few have permeated U.S. models due partly because of the nature of data requirements that go beyond traditional modeling requirements.
- Developments in spatial referencing are beginning to be used in origin/destination matrix creation, but few models appear to have this capability. Even if they do, this aspect is not very clear from the literature review.
- In Oregon, freight is modeled along with passenger travel simultaneously within an integrated model. These models have several advantages but are extremely data-hungry, require much more than traditional modeling efforts, and require a greater level of technical expertise in terms of running the model. More recently in the U.S., micro-simulation is being promoted as a way of modeling emergent behavior and logistics relations in freight delivery. Micro-simulation is also being applied in statewide efforts in Oregon.

- Alternative methods are emerging that tend to question commercially used flow data and instead propose bottom-up type approaches that instead rely on I/O models and economic forecasts to generate their flow matrices.
- Methods adopted need to consider several criteria. Candidate criteria could include:
 - data;
 - technical expertise;
 - ultimate use of models and what type of questions they will need to answer;
 - whether there will be an integration with urban models or not
 - graphical user interface; and finally
 - the need to develop models that will be amenable to future updates/improvements.

CHAPTER 3 – TEXAS STATEWIDE ANALYSIS MODEL

Passenger and freight transportation are experiencing high growth in Texas. The need for a comprehensive multimodal - freight and passenger - transportation planning process is revealed with increasing congestion levels in urban areas and rural corridors connecting large urban areas. TxDOT builds and maintains travel demand models for most of the urban areas within the state with populations greater than 50,000. These models typically follow the traditional three-step process, trip generation, trip distribution, and trip assignment. The TxDOT urban travel demand models use a custom trip generation program called TRIPCAL5, a custom atomistic gravity model called ATOM2 for distribution, and an equilibrium assignment option within the software package TransCAD.

The Texas Statewide Analysis Model (SAM) was developed as a suite of three separate models: the statewide passenger model, the statewide freight model that covers the state of Texas, and a combined freight model covering the U.S. and Mexico. This chapter discusses the freight component of the Texas SAM, and compares this model to other experiences revealed during the literature review and state and MPO surveys.

SAM ZONE STRUCTURE

The SAM zone structure covers Texas and the immediate surrounding area with a one-county-deep buffer around the state. The zone structure includes 4600 internal zones and 142 external stations. The SAM zone structure is not as detailed in the 24 urban areas in Texas that have travel demand models. The SAM zone structure in modeled urban areas allows the number of SAM zones to remain in a manageable range. The average zonal population of most counties is between 1000 and 2000, except for the 16 “urban area” counties where the average zonal population is over 4000, with the seven highest averages (over 9000) all being in Houston, Dallas, and San Antonio. The SAM zonal system within the urban areas is consistent with the urban zonal system in that the urban zones may be aggregated to match the SAM zones.

SAM FREIGHT DATA

The Texas SAM freight model uses the 1998 Reebie Transearch database as the main source of commodity flow information. The benefits of using the 1998 Reebie data are consistency with the passenger flow forecasting as it also uses a 1998 base year, with available traffic counts, and with 1998 base year demographic data forecasts.

Six major components of freight demand are identified for the analysis. For each of the six components, commodities types are grouped as determined in the model development process. The six components include:

- Texas Agricultural Movements,
- Texas Intrastate Movements,
- Texas Interstate Movements,
- Texas – Mexico Movements,
- Mexico – Remainder of U.S. Movements Passing Through Texas, and
- United States – United States Movements Passing Through Texas.

Table 3.1 presents a summary of the 1998 tonnages from the 1998 Reebie databases.

Table 3.1. Summary of 1998 Reebie Freight Flow Data – Annual Tons.

Movement Type	Annual Tons by Mode of Transport				
	Truck	Rail	Water	Air	Total
Texas Agriculture	21,684,015	0	0	0	21,684,015
Intrastate	418,521,640	38,925,203	74,338,604	166,729	531,952,176
Interstate	248,730,683	163,410,923	34,307,602	1,247,480	447,696,688
U.S. – U.S. Through	56,511,713	45,170,117	2,119,827	721,424	104,523,081
Mexico – Texas	6,627,952	1,437,947	0	832	8,066,731
Texas – Mexico	16,662,111	1,973,511	0	360,123	18,995,745
Mexico – U.S. Through	9,469,006	2,869,521	0	0	12,338,527
U.S. – Mexico Through	16,579,966	10,005,728	0	0	26,585,694
Total	794,787,086	263,792,950	110,766,033	2,496,588	1,171,842,657

The Texas agricultural movements relate to the movements of agricultural products to/from farm sites to/from processing distribution centers, and are primarily short distance movements carried only by truck.

Intrastate movements include those with both origin and destination within the state of Texas (excluding agricultural movements), and make up about 45 percent of all movements. Trucks carry 79 percent of these shipments. Rail and water modes account for 7 and 14 percent, respectively.

Interstate movements include those with one end in Texas and the other outside Texas, but within the U.S. The interstate movements make up about 38 percent of all movements. About 44 percent of these movements are made by non-road modes (about 36 percent by rail and 8 percent by water).

In 1998, freight movements between Texas and Mexico accounted for about 2 percent of all Texas movements. Most of this traffic was carried by truck (about 85 percent) with the remainder by rail.

The Mexico – U.S. Through and U.S. – U.S. movements are a function of economic activities outside of Texas. The future forecast for these movements was obtained directly from Reebie Associates (35). Total movements through Texas accounted for about 12 percent (Mexico – remainder of U.S. through traffic was about 3 percent) of freight moving across the state’s transportation system. About 57 percent of these movements were by truck with the remainder predominately by rail.

Commodity Grouping

The base year flow data included approximately thirty commodity types. A smaller number of commodity types, however, represent over 90 percent of all tonnage. Commodity types and tonnages within each major flow generation category were reviewed to identify the most significant commodities within each movement group (intrastate, IE, and external). Table 3.2 shows the grouping of “major commodities” for each of the three types of movement.

Table 3.2. Major Commodity Flows.

Commodity Type	External-Internal		Internal-External		Intrastate	
	Tonnage	Percent of Total Tonnage	Tonnage	Percent of Total Tonnage	Tonnage	Percent of Total Tonnage
1– Farm Products	21,473,987	8.8	NA	NA	NA	NA
11 – Coal	45,375,228	18.6	NA	NA	20,060,927	3.8
14 – Nonmetallic Materials	3,716,072	1.5	NA	NA	18,428,772	3.5
20- Food or Kindred Products	30,476,299	12.5	19,302,762	9.7	76,254,891	14.3
24 – Lumber or Wood Products	10,676,387	4.4	5,273,643	2.7	37,999,219	7.1
26 – Pulp, Paper or Allied Products	7,311,188	3.0	3,626,948	1.8	NA	NA
28 – Chemicals or Allied Products	31,785,888	13.0	63,978,506	32.2	78,075,014	14.7
29 – Petroleum or Coal Products	16,696,710	6.8	51,477,751	25.9	118,048,530	22.2
32 – Clay. Concrete or Stone	10,458,922	4.3	4,536,833	2.3	67,732,713	12.7
33 – Primary Metal Products	15,025,727	6.2	10,462,961	5.3	9,610,721	1.8
34 – Fabricated Metal Products	3,929,748	1.6	3,017,781	1.5	NA	NA
37 – Transportation Equipment	11,230,438	4.6	8,109,219	4.1	NA	NA
40 – Waste or Scrap Materials	3,925,724	1.6	NA	NA	NA	NA
46 – Miscellaneous Mixed Shipments	6,241,168	2.6	5,864,124	3.0	NA	NA
50 – Secondary Traffic	11,335,323	4.6	7,196,416	3.6	75,949,377	14.3
All Other Commodities	14,243,108	5.8	15,928,325	8.0	30,490,368	5.7
Total	243,901,917	100.0	198,775,269	100.0	532,650,532	100.0

A set of commodity groups was defined for initial regression analyses. Eleven groups were defined, with three of them not having a “major commodity.” Commodities in these three groups were not considered to be sufficient similar to any of the defined “major commodity types” to be included in the group. Table 3.3 shows the grouping of commodities with “major commodity” types shown in bold typeface. Three commodities — metallic ores, coal and crude petroleum — were assigned to the Raw Material commodity group. The simple correlation analysis suggested that they were not strongly correlated with any of the available demographic variables, and therefore no regression analysis was attempted.

Table 3.3. SAM Commodity Grouping Scheme.

Commodity Group	Commodity Type (STCC2)
1. Agriculture	1 Farm products 8 Forest products 9 Fresh fish
2. Raw Material	10 Metallic ores 11 Coal 13 Crude petroleum, natural gas, or gasoline 14 Nonmetallic ores, minerals, excluding fuels
3. Food	20 Food and kindred products 21 Tobacco products, excluding insecticides
4. Textiles	22 Textile mill products 23 Apparel or other finished textile products or knit apparel 30 Rubber or miscellaneous plastics 31 Leather or leather products
5. Wood	24 Lumber or wood products, excluding furniture 25 Furniture or fixtures 26 Pulp, paper, or allied products 27 Printed matter hazardous substances
6. Chemicals, Petroleum	28 Chemicals or allied products 29 Petroleum or coal products
7. Building Materials	32 Clay, concrete, glass, or stone products 33 Primary metal products 34 Fabricated metal products
8. Machinery	19 Ordnance or accessories 35 Machinery, excluding electrical 36 Electrical machinery, equipment, or supplies 37 Transportation equipment 38 Instruments, photographic goods, optical goods, watches, or clocks 39 Miscellaneous products of manufacturing
9. Miscellaneous	40 Waste or scrap materials not identified by producing industry 41 Miscellaneous freight shipments 42 Containers, carriers or devices, shipping, returned empty 43 Mail or contract traffic 44 Freight forwarder traffic 45 Shipper association traffic 46 Miscellaneous mixed shipments 47 Small packaged freight shipments
10. Secondary	50 Secondary Traffic
11. Hazardous Materials	48 Waste hazardous materials or waste 49 Hazardous materials or substances

Note: Major commodity types shows in bold type.

Forecast Data

The Wharton Economic Forecasting Associates (WEFA – now Global Insight) provided the Texas Department of Transportation Statewide Planning Study the base (1998) and forecast year (2010, 2020) estimates of freight flows within, to, from, and through the state. No traffic to/from Mexico and the U.S. was included in the forecast.

SAM TRIP GENERATION, DISTRIBUTION, MODE CHOICE, AND ASSIGNMENT

Trip Generation

Reebie origin-destination flows are defined at the county level, therefore all trip generation models, as well as other freight model components, were developed at the county level of geography. No finer level of disaggregation was possible for model development.

Regression analysis is a generally accepted approach to develop generation models that are consistent with the available demographic data variables. The regression equations relate independent variables to the tonnages produced or attracted at the county level. The variables that were used include employment types – basic, retail, and service employment – and dummy variables representing special freight handling facilities. Regression equations were developed for the following freight movement types, by commodity group:

- Internal-Internal Productions,
- Internal-Internal Attractions,
- Internal-External Productions, and
- External-Internal Attractions.

No relationship was found between the available independent variables and tonnages for three commodity groups – Agriculture, Raw Materials, and Hazardous Materials. Miscellaneous Mixed Freight by definition only moves by rail or water, therefore, no truck movements are part of this commodity group. No regression equations were estimated for these four commodity groups and the Reebie tonnage flows were used as the base year, and WEFA estimates of growth were applied for future forecast.

The trip generation model is applied using the TransCAD GISDK program that is called from the SAM freight model user interface.

Trip Distribution

Initial applications of the distribution models were found to significantly over and under estimate some movements between sub-areas of the state. K-Factors were used to correct the model's discrepancies with the observed flow patterns from the Reebie data. K-factors are used to adjust initial model results to acceptably reproduce observed sector-to-sector movements within the state.

K-factors were calculated for each sector-to-sector movement and input to a subsequent application of the distribution models. This iterative process - review results, calculate new factors, reapply distribution models - was applied until an acceptable observed versus estimated comparison was achieved.

The model calibration was done by summarizing observed trip length distribution by commodity groups using the same movement types as in the trip generation analysis – intrastate, IE, and EI.

Travel time and distance were examined for use as the distribution function impedance variable, selecting travel distance as the impedance measure as it allowed the model to maintain a consistency in distribution patterns over time.

Commodity groups having similar characteristics were aggregated into larger groups for development of distribution functions and model calibration. The trip length distributions of the combined commodity groups were used to calibrate distribution functions that matched the observed trip length distribution.

Distribution functions were developed for the Gamma Function model using the TransCAD distribution model calibration functions. The model was defined as being ‘doubly constrained’ — output matrix flow productions and attractions must match input values as well as the trip length distributions.

Mode Choice

After testing various probability models that estimate modal shares, the logit model formulation was selected. Under this approach the share to a given mode is estimated as a function of the mode’s travel times and costs relative to the other available modes.

Freight Model Validation

Model validation work consisted of applying the trip generation, distribution, and mode choice models to obtain estimates of freight tonnage and vehicle flows. These flows were compared to two sources of actual freight flows: the 1998 Reebie databases and 1998 traffic counts of heavy commercial vehicles. The initial comparisons between the estimated and observed data found significant differences that led the modelers to make revisions to the original forecasting models to improve their performance.

Commodity groups 1, 2, 9, and 11 (Agricultural, Raw Material, Miscellaneous Mixed, and Hazardous Materials) accounted for only 10 percent of all intrastate movements (on a tonnage basis), and it was not possible to find reliable relationships between movement of these freight types and the available independent variables. Therefore, the base year Reebie flows were used to represent these movements in the validation tests.

Initial comparisons found unacceptably large differences that led to the development of a series of ATOM2 bias factors (k-factors) for each commodity group. These factors were derived in an iterative fashion until acceptable comparisons were achieved with the Reebie observed data.

Comparisons between Reebie and model estimates of tonnages produced and attracted by district and inter-sector movements indicate that the models produced a generally acceptable replication of Reebie data by commodity group. These results suggest that the trip generation and distribution models were producing acceptably accurate estimates of observed freight demand.

The mode choice models accurately estimated the split between road and rail across the full range of origin-destination combinations. The traffic assignment comparisons indicated that the model estimates were within a range defined by total and heavy truck (tractor trailer vehicles) counts for rural highways and somewhat lower than heavy truck counts for urban roads. The low

value for urban roads is expected, as the freight models do not include local, short-distance movements.

Conversion of tons to trucks was performed using load factors. Vehicle load factors were revised from single values associated with individual commodity groups to a range of values related to trip length. Load factors were also increased by about 15-20 percent to better match traffic count data. The developers had to adjust load factors and the percentage of empty trips. After these adjustments, empty truck movements accounted for about 25 percent of total truck vehicle miles of travel (VMT).

Assignment

Before performing the assignment, the SAM model results had to be converted from annual figures into daily trips. The average daily trip tables were obtained by dividing the annual values by 365 (the number of days in a year).

The TAZ level truck vehicle assignment was run on the same network as the passenger assignment with the same 4742 centroids. A high-occupancy vehicle (HOV) type assignment was used for the joint assignment of trucks and passenger vehicles. The HOV assignment option in TransCAD is a multi-class assignment. Freight truck movements were loaded as the initial step in traffic assignment. Truck movements were assigned to the road network using minimum travel time paths. The all or nothing assignment procedure was used because only truck trips were assigned in this step. Roadway capacities were adjusted to account for truck traffic and the adjusted values used to calculate congestion impacts on road speeds and passenger vehicle route selection.

SAM COMPARISON

The findings from the literature review and the state/MPO surveys (Chapter 2) were compiled to facilitate a comparison of the SAM with other statewide modeling efforts. This chapter focuses on the comparison of the current operational version of SAM with models either currently operational or those that are being developed in other states for freight planning purposes.

From the twelve states that reported having a freight statewide model, four including Texas use the typical four-step process, and six use a simplified version of the sequential process. Ohio and Oregon reported developing integrated land use transportation models. Table 3.4 presents a general classification of the statewide models.

Table 3.4 .Statewide Model Classifications.

Sequential			Integrated Land Use
Commodity-Based Four-Step	Commodity-Based Three/Two Step	Vehicle-Based Truck-Only	
Texas Florida Indiana Michigan	Louisiana Maine Virginia Wisconsin	New Jersey Vermont	Ohio Oregon

The majority of the statewide freight models examined follow a sequential process with the typical four-step process or simplified versions of it. One common practice combines the trip generation and trip distribution steps to produce trip tables. This process is usually performed using commercially available commodity movement information as input, to generate zonal flows by commodity group and mode. This trip generation-trip distribution combination technique could have a total of three steps if the process following the creation of trip tables is a modal split, or two steps if the matrices are produced for only one transport mode and the next step is the assignment of trips to the network. A third variance of the sequential model techniques is the one followed by New Jersey and Vermont, in which only one mode of transport, in this case trucks, is used during the analysis. The trip generation step is performed only for trucks and, therefore, there is no modal split step.

A detailed comparison was performed on general characteristics of the models that included model type, coverage, network and zone structure, modes analyzed, model output and status. Table 3.5 shows a general comparison of SAM with other statewide models. The table is followed by a detailed comparison of each step of the four-step process (generation, distribution, mode split/choice, and assignment). Table 3.5 indicates that modeling efforts of states range from variants of the four-step process to more complex modeling involving embedding the freight component as part of a larger framework of transportation and land use looking at freight and passengers simultaneously. Transportation networks and zoning structure were found to be similar between all models with a geographic coverage of the state and surrounding area, and zonal aggregations that have some relationship with the passenger travel demand model structure. Ohio and Oregon are in the process of developing integrated land-use transportation models. The rest of the surveyed statewide models have sequential modeling processes.

Table 3.5. SAM: General Characteristics Comparison with Other Models.

State	Model Structure and Basic Characteristics	Coverage Zone Structure Network	Results	Operational Status
Texas	Four-step multimode (truck and rail) model designed to use the same data and framework as passenger model. Eleven commodity groups	Covers the state with a total of 4600 zones (4400 within Texas). Zones are based on census block groups aggregated to be compatible with urban model zones.	Capable of forecasting statewide traffic volumes by mode and mode shifts	Operational, Alliance–Texas, Wilbur Smith Associates recently delivered the final version to TxDOT
Florida	Four-step, commodity-based, multimodal model with long haul truck assignment only. Thirteen commodity groups are used by combining Standard Industry Codes (SIC).	The statewide zones are aggregations of urban and regional zones, with a total of approximately 4000 zones. The highway network is the same as the statewide passenger model.	The freight model forecasts tonnages by commodity and these are converted to trucks. Forecast is based on future demographics.	The model needs to be validated (Cambridge Systematics) (31). Urban interfaces envisioned for future versions.
Indiana	Four-step, commodity-based, multimode (rail/truck) model. Uses 21 commodity-groups at 2 digit Standard Transportation Commodity Codes (STCC) level	County-level TAZ structure, with 92 counties and 53 TAZs representing the remaining 47 contiguous states and DC. Truck and rail networks from U.S.DOT sources.	Predicts truck and rail traffic volumes that are converted into number of trucks and railcars using rates by commodity-group. Volumes are expressed in daily traffic figures	Originally developed in 1997 by W.R. Black (34), Cambridge Systematics currently working on upgrades.
Louisiana	Three-step, commodity-based with truck assignment only. Commodity groups were used to produce commodity flow matrices.	State of Louisiana county-level zone system (300 zones) and BEA level for surrounding areas. The freight component uses same highway network as passenger travel demand forecasting model	The truck model uses forecasted commodity flows that are converted to vehicle trips.	Wilbur Smith Associates working on the final stages
Maine	Two-step, commodity-based, truck only model. Four commodity groups used (food products, wood/paper products, stone, mineral, clay, glass and chemical products, and other products)	The statewide freight model uses the same zone structure and network as the passenger model consisting of 1509 TAZs, and the network is Maine’s statewide road network.	The freight model will predict freight flows that will be converted to truck trips.	Additional vehicle classification counts on major roadways and truck trip survey are needed to calibrate the truck model.

Table 3.5. SAM: General Characteristics Comparison with Other Models (Cont.).

State	Model Structure and Basic Characteristics	Coverage Zone Structure Network	Results	Operational Status
Michigan	Four-step, commodity-based, truck only model. Twenty six product categories (commodity groups) are used based on STCC	The freight model uses 131 county-level "Commodity Analysis Zones" (CAZ) for trip generation purposes, and then disaggregated into 2,392 TAZs (2307 instate, 85 outside)	The model estimates tons of commodities, which are converted to annual truck movements, with an option to estimate commodity values.	Model being updated by the state DOT. Retail and service sectors will be added to replicate current commercial traffic counts
New Jersey	Three-step (no modal split), vehicle-based model	The model covers New Jersey and adjacent regions with 2,800 TAZs. Same highway network as the one used for passenger modeling	The model forecasts truck (medium and heavy) volumes, estimating daily traffic annual average daily traffic (AADT).	Model validated, recently used on various alternatives analyses for the NJDOT Newark / Elizabeth Portway Study
Ohio	Integrated land use transportation model that includes commercial and personal travel. Single unit truck, tractor trailer unit truck, rail, auto or van, water and air cargo modes	The model includes a total of 7,500 zones, 2,500 outside Ohio, 3750 in Ohio MPO areas, and 1250 in Ohio non-MPO areas. The zones nest into counties	Value of freight by mode (shipment volumes), calculating interzonal flows in dollars by sectors which are converted into tons and number of trucks	Under development by Donnelly, Hunt and Costinet. Scheduled for completion in 2005. Interim model capabilities currently exist.
Oregon	Integrated land use transportation model. Divides freight into 8 economic sectors and truck weight category	Different zone system than the urban transportation model, with 122 zones. The networks include highways and local arterials	Used for trade flow forecasting, calculates interzonal flows in dollars by sectors which are then converted into tons and trucks.	Used to analyze consequences of transport and land use policies. Generation 2 model currently under development
Vermont	Four-step, vehicle-based, truck only model.	The model uses 999 TAZs consisting of census blocks or aggregations of them in urbanized zones. The network is the GIS layer of Vermont's National Highway System (NHS) with some local roads added to provide network continuity.	The model estimates truck traffic and assigns it to the highway network using equilibrium assignment.	Under development by Cambridge Systematics, initial calibration completed
Virginia	Four-step, commodity-based model that assigns only trucks to highway network.	The multimodal model has over 1,200 TAZs including census tracts within Virginia and external zones covering portions of West Virginia, Maryland and Tennessee. Highway network includes all roadway links from the NHS.	Forecast freight flows resulting from changes in the statewide mobility system or demand. Flows are converted to truck movements	Under development by Wilbur Smith Associates, planned to be finalized by the end of 2003
Wisconsin	Truck/Rail/Water/Air input -output model. No conventional trip generation step. Only truck flows are assigned to network. 39 commodities by 2-3 digit STCC	Coverage consists of state, the remainder of the U.S. and Canada, with 140 zones (72 counties in Wisconsin and 68 external). External zones range from counties in the periphery to BEAs, states and Canadian provinces. Highway and rail networks	Estimates freight traffic by mode. Flows by weight are converted to equivalent number of vehicle daily flows.	Developed by Wilbur Smith Associates in 1996, used recently to analyze truck-rail modal diversion.

Trip Generation Comparison

The SAM model is compared with other 4-step models, which have trip generation or will have this step when completed. Texas SAM has not been compared to Oregon and Ohio approaches even though generation is involved in these models.

Texas SAM

The Texas SAM model uses Reebie flow data in conjunction with demographic data (at the county level, 254 counties are used). Regression methods were used to determine generation equations for commodity productions and attractions. Regressions were developed at the county level linking flow tonnage as functions of aggregated employment in basic sector, retail sector, or total employment. Regressions were run separately for II trips (separate regressions for intrastate origins and destinations), IE origin tonnages, and EI destination tonnages.

Texas SAM uses 38 commodity groups (two-digit STCC) including “secondary traffic” that were aggregated to 10 groups with similar “transportation characteristics” and categories that formed about 90 percent of the total tonnage. The 10 commodity groups that were formed are shown in Table 3.6.

Table 3.6. Commodity Groups Considered in Texas SAM Generation Stage.

Commodity Group	Commodity STCC2
1. Agriculture	1,8,9
2. Raw material	10,11,13,14
3. Food	20,21
4. Textiles	22,23,30,31
5. Wood	24,25,26,27
6. Chemicals, Petroleum	28,29
7. Building Materials	32,33,34
8. Machinery	19,35,36,37,38,39
9. Miscellaneous	40,41,42,43,44,45,46,47
10. Secondary	50

The original regression performed well for some groups but poorly for groups 1 and 2. Further analysis was conducted to improve model specification by stratifying the counties by population and the calibration data set was split into two groups: counties with populations less than 200,000 (234 counties), and counties with populations greater than 200,000 (20 counties), via outlier examination and by use of detailed employment as regressors (as opposed to aggregate sector employment). Data source for employment was the Census Bureau’s County Business Patterns.

Regressions were conducted separately and TRIPCAL5 software used to generate the actual commodity productions and attractions. TRIPCAL5 was also used in the passenger demand component.

Indiana Model

The structure of the Texas SAM trip generation model is very similar to that adopted in Indiana. The zonal structure is the same (county level). Researchers considered 21 commodity groups and trip generation equations were developed based on regressions of flow data (from 1977 Census of Transportation, 1993 CFS (non-manufactured goods)) on several variables, which included employment in specific SIC/STCC classes, tons shipped or received, total employment, and cash receipts where applicable.

Florida Model

The model has been defined to analyze long-haul truck movements (truck movements with more than 200 miles) in the state and has 14 commodity groups. Demographic variables like employment and population form the basis of generation of commodity volumes. The trip generation equations are linear regressions of Reebie data on population and SIC employment on a county basis. The relations established at the county level formulate the basis for disaggregating to TAZ level for freight model implementation and validation.

Vermont Model (Under Development)

Separate models are used for trip productions and attractions. The trip production model uses standard QRFM techniques with 10 employment categories, i.e., Agriculture/farming, Mining, Contractor, Food/wood, Metal, Transportation/Construction/Utilities, Financial/Insurance/Real Estate, Services, Wholesale and Retail. QRFM methods and the Vancouver truck model were used to develop production rates, which were scaled back during model calibration.

Trip attractions are estimated using input-output Bureau of Economic Analysis national tables. Production/Attraction rates were developed by evaluating the I/O characteristics and adjusting them to Vermont. This method formed the basis of zonal trip attraction prediction.

Michigan Model

Commodity tonnages are generated at the county level within the state. Twenty-six categories were used (STCC 1-39, with some gaps). It appears that Input/Output accounts were also used to estimate attractions for each county-level CAZ, based on consumption of industrial products by the industries and households residing in them. Not enough detail was obtainable from the Michigan model from either the survey or the literature review to clearly indicate the approach adopted.

New Jersey Model

The trip generation component is developed using employment by classification and surveys for travel patterns. Special generators are modeled separately.

Trip Generation Summary

Operational models with a trip generation component have used either simple QRFM techniques or regression approaches to obtain productions and attractions. Some of the models like Florida and Indiana (basic structure is a CBM) and Vermont (basic structure is a VBM) are using

regression type approaches. With respect to trip generation, the Texas SAM is consistent with existing operational models and some ongoing developments elsewhere. It is noted, however, that with regression approaches model specification issues are critical. It is even more critical in a state the size of Texas. As indicated in the literature review, there are several ongoing national and regional efforts that will lend to the extensions of the state of the practice in this critical step of freight demand forecasting.

Trip Distribution Comparison

Texas SAM

The Trip Distribution process in the Texas SAM was performed using a “doubly constrained” GM. The doubly constrained GM requires that the output matrix flow productions and attractions must match input values and the resulting trip length frequency distribution must match the desired or observed distribution. Three alternative distribution functions were tested, and the GM friction factor curve with an exponential power function produced acceptable results. After examination of distance and time as potential impedance variables, travel distance was selected for use as distribution impedance variable, allowing the model to maintain a consistency in distribution patterns over time.

Calibration of the distribution model was performed only for two trip types — intrastate and Texas-other U.S. Future freight movements passing through Texas and between Mexico and Texas will be derived from Wharton Econometric Forecasting Associates (WEFA) forecasts of Texas Overhead Traffic, base year estimates of Texas-Mexico freight movements will come from Reebie and Latin American Trade and Transportation Study (LATTTS) growth rates for Mexico – U.S. traffic. Therefore, the “through Texas” and “Mexico-Texas” freight movements will not be determined using distribution models.

Other States

Tabel 3.7 presents a comparison of the trip distribution characteristics of the SAM and other four-step process models. All of the other states that have the same type of model use the gravity model with distance as the friction factor variable. Validations data used vary by state, some of them using Reebie data as Texas, others using CFS and local surveys.

Table 3.7. Trip Distribution Comparison of Four-Step Models.

State	Gravity Model	Validation Data	Friction factors
Texas	Doubly Constrained	1998 Reebie	Distance
Florida	Yes	Reebie	N/A
Indiana	Yes	1993 CFS	Distance
Michigan	Doubly Constrained	1993 CFS, 94 and 96 truck intercept surveys	Distance
Vermont	Yes	O-D Surveys	Distance

Non Four-Step Process Models

As shown in Table 3.5, Louisiana, Maine, Virginia, and Wisconsin have developed a simplified version of the traditional four-step process. These models combined trip generation and trip distribution steps to produce trip tables using the following general procedure.

1. Total freight flows are determined using Reebie data or CFS for each commodity group. If these sources of information do not provide particular flows of interest to the state, the data could be complemented with flow studies.
2. Freight origins are identified and assigned to county-level TAZs, based on county employment data.
3. Based on national input-output table, it is determined which proportions of each commodity group is destined for industrial consumption and which is destined for household consumption.
4. County-level destinations are allocated based on employment (for industrial consumption) and population (for household consumption).
5. Resulting commodity flows are converted to vehicle trips using factors derived from truck weight surveys, railcar weight information or other vehicle-weight ratios by commodity group.

Trip Distribution Summary

Texas SAM and four other states use the same distribution technique applying a gravity model with distance as the friction factor variable. Five other states were identified that use a simplified version of the four-step process, which is not comparable to the SAM model process.

Mode Choice Comparison

As part of a combined literature review and survey effort, 16 states were identified as having freight statewide models either operational or under development. These 15 models are divided into truck-only models and those that consider multiple modes. This separating is essential because only those that look at multiple modes will have a mode choice/split/diversion component associated with them. Some states like Florida are truck only models but they are inter-modal to start with because only the truck trip tables obtained are carried forward to the assignment after the mode split process.

States with Truck-Only Models

Iowa
New Jersey
Kansas
Vermont (under development)
Kentucky
Maine
Michigan

States with Multiple-Mode Models

Indiana
Florida
Virginia (under development)
Ohio (under development)
Oregon (under development)
Louisiana (under development)
Wisconsin
Texas

The following summary documents what researchers know about mode choice steps included as part of statewide models with multiple modes. Models tend to fall into two different categories; sequential models (four-step, three-step models), and non-sequential models based on integrated transport land use interactions. Ohio and Oregon fall into the non-sequential models and cannot be directly compared to other models.

Texas SAM

Incremental logit models were used for II trips only to estimate change in mode shares as a function (change in time and cost relative to other modes) of using base year data for the zone (county). Aggregative data for broad commodity groups were used. Distance based on trip length was used as a proxy for cost. Access distance (county proximity to rail access) was also included. Modes included trucks, rail, and water. Trips with one end outside the state like EI, IE, and through trips were excluded. In these cases, the mode shares for future years were assumed to be the same as the base year or allowed to change by a designated amount only- called the “policy mode share” approach. The following independent variables were tested for inclusion in logit models by commodity group:

- mode mainline cost,
- mode mainline time,
- rail access cost, and
- total tons between the county pair.

For some groups (first eight shown in Table 3.8 below) standard binary logit was used (rail/road mode) and for other multinomial logit was used (rail/road/water) (categories 2, 6 in Table 3.8). However, multinomial models with water as another mode were dropped in the validation stage. Table 3.8 shows the 11 groups considered in a mode choice step that were formed.

Table 3.8. Commodity Groups Considered in Texas SAM Mode Choice Stage.

Commodity Group	Commodity STCC2
1. Agriculture	1,8,9
2. Raw material	10,11,13,14
3. Food	20,21
4. Textiles	22,23,30,31
5. Wood	24,25,26,27
6. Chemicals, Petroleum	28,29
7. Building Materials	32,33,34
8. Machinery	19,35,36,37,38,39
9. Miscellaneous	40,41,42,43,44,45,46,47
10. Secondary	50
11. Hazardous Materials	48,49-Primarily rail mode

Predicted results were compared to existing mode choice (splits) as represented by Reebie flow data. Future year mode shares use existing shares combined with change in shares estimated from logit models. Binary mode choice models based on time, cost (classified by commodity

type) relations, and based on existing Reebie data formed the basis of estimating change in base year shares to obtain new mode shares for rail/road modes.

Florida Model

County-to-county trip matrices between Florida counties and North American regions outside Florida obtained from regional (urban models) and updated statewide networks are reported to have been used to provide information for both trip distribution stage and mode choice stage. The existing mode split observed in TRANSEARCH Reebie data was the primary basis for forecasting mode splits. The mode split model was limited to truck/rail modes and based on utility variables and coefficients developed from a stated preference survey and the TRANSEARCH Reebie data. Incremental logit models based on stated preference surveys were reported to be the basis for mode split. These equations do not allow direct estimation of mode share. The logit equations are applied to change in utilities resulting from changes in cost or time to estimate a percentage change to apply to base year mode share obtained from existing Reebie data. One trip table is estimated for each of the 14 commodity groups and for each mode (five modes: rail, water, intermodal rail, truck, and carload rail) producing 70 trip tables by commodity by mode.

Indiana Model – Mode Choice/Split

A mode split computer program called NEWMODE utilizing 1993 CFS data for 9 single modes and eight multiple mode categories was used. Seventeen modes were examined in terms of variable distances (less than 50, 50-99, 100-249, 250-499, 500-749, 750-999, 1000-1499, 1500-1999, 2000 miles or more). Hence, mode splits are developed by commodity and distance, since distance is a significant factor in mode split as length of rail hauls exceeds the average length of truck hauls for most commodities. Observed data appear to be the basis for mode splits. It was not clear whether choice models were or were not used as part of this process. It appeared that historical mode splits may have been used in a trend-like fashion.

Virginia Model (under Development – To be completed 2003)

Three modes are considered: truck, rail, and water. The model was scheduled to include intermodal facilities and major ports. Mode choice was used on the passenger component and to model modal shares given various competing mode's time and cost characteristics for a given set of socioeconomic characteristics. As far as the freight component was concerned, no detail was available at the time to assess specifically how mode split would be addressed.

Wisconsin Model (Mode-Diversion)

Wisconsin model considers two modes: truck and rail. Thirty-nine commodity groups were used and several rail-truck intermodal diversion scenarios were considered. The mode diversion was based on expert panel opinions on rail/truck splits based on two key variables shipment distance, and frequency of rail service.

Ohio and Oregon (under Development)

These models fall into a different class of models that are based on integrated models and cannot be directly compared to Texas SAM or other models discussed above. However, it is important to note that these models incorporate multinomial logit models of movements between individual production and attraction zones to specify the mode choice process.

Mode Split Summary

In summary, there are few instances of explicit modeling of mode-choice/split aspect in statewide freight modeling. The freight models examined indicate that commodity characteristics, cost, and time are key variables (time could be expanded to include dependability and frequency of shipment). These variables are consistent with those that have been used in passenger demand modeling. Quality and access have also been suggested in the literature but do not appear to have been used with the exception of the Texas SAM model that attempts to include access distance. The calibration data used are typically aggregative except for Florida which utilizes disaggregate shipper data. As indicated earlier, the Oregon effort also utilizes disaggregate shipper data for this stage of the analysis. The model specification and nature of calibration data can impact model accuracy in mode share prediction.

Trip Assignment Comparison

The Texas SAM uses an all-or-nothing technique for the freight portion. Truck flows were assigned to the highway network following this approach. Before performing the assignment total flows were converted to equivalent vehicles. There was not a lot of information on the assignment procedures for other states, but of the ones that provided information all stated the use of all-or-nothing technique. It was found that some of the other multi-modal statewide models pre-load the truck matrices into the network before the passenger vehicles are assigned to assure that trucks are assigned to major links.

Model Output: Tonnage vs. Vehicle Trips

Several statewide models provide outputs in terms of truck trips either individually or in conjunction with flow volumes. The type of output is largely a function of whether a model uses flow databases or not. If flow databases are used, output can be commodity flows, vehicle trips, or both. If trips are reported, conversion of flow output is typically conducted using VIUS or HPMS data. VIUS provides truck payload data by commodity classification.

None of the states in the survey output indicated the methods used to convert the flows to trips. Hence, this part of the project was entirely done via literature reviews and existing documentation. Florida, Vermont, Indiana, Louisiana, currently appear to produce output that actually indicates number of truck trips. Texas SAM model produces estimates of flows rather than trips. If trips by mode are required, then a conversion will be required of flows to trips.

CHAPTER 4 – URBAN FREIGHT/COMMODITY MODEL STRUCTURE

One of the primary objectives of this research is to develop a post processor model for the integration of the SAM freight results into the urban area travel demand models. The purpose of this chapter is to present and discuss some options and alternatives for accomplishing this objective as well as the secondary objectives of developing models to predict the intra-urban area movements of commodities including those generated internally and as a result of the movements into the area from outside the area, i.e., state, regional, and national movements.

Within the context of an urban freight/commodity model, several constraints and criteria are recognized as influencing the model, both in design and implementation. These criteria are summarized as follow:

- There are 25 urban areas within Texas that have an urban travel demand model. A model to predict urban freight/commodity movements should be flexible enough to be used within the current modeling system for those areas.
- A model to predict urban freight/commodity movements within urban areas should utilize to the extent possible current data and software that are available and used within the urban travel demand models for predicting current and future movements.
- A model to predict urban freight/commodity movements within urban areas should build upon and maintain consistency with the results of the statewide model.
- A model to predict urban freight/commodity movements will have limited data and information for calibration. There are national data sources that provide estimates of commodity flows at regional, state, and national levels. The most common lowest level of estimate is county-to-county movements. Little information is available on movements within urban areas (many are contained wholly within a single county).
- The modes used to transport freight/commodities include trucks, rail, water, air, and pipeline. Most of these modes are not viable for inclusion in models predicting commodity movements within urban areas but must be considered relative to the impact movements by those modes have on commodity movements within urban areas. For example, within an urban area, commodities are very unlikely to move by air between internal zones but it is likely commodities will be brought into the area by air from outside sources. This action simplifies the development of a model to estimate commodity movements within an urban area because the number of modes may be reduced to one, i.e., trucks. Rail is not considered a viable alternative mode for movements within urban areas because the general rule in the industry is that rail is not viable (i.e., competitive) for freight movements that are less than 500 miles in length (51). It is generally conceded that the distribution of commodities within urban areas is done almost entirely by trucks and the movements of commodities into, out of, and through urban areas involve multiple modes including trucks, rail, water, air, and pipelines.
- The estimates of commodities from the Texas SAM are in annual tons. To be integrated into the urban travel demand models, these estimates must be converted to daily tons. This conversion is done by dividing the annual estimates by 365.

This research has subsequently been directed toward developing an urban freight/commodity model under the following criteria:

- movement of commodities into, out of, and through urban areas by truck, rail, air, and water are estimated using the Texas SAM;
- integration of the estimates from the above into the urban travel demand modeling system;
- estimate intra-urban movements of freight/commodities by truck; and
- incorporate the externally related commodity movements by other modes (i.e., rail, water, air, and/or pipeline) through exogenously generated estimates for identified special generators.

The proposed urban freight/commodity model essentially follows the same steps as the passenger travel demand models, i.e., generation, distribution, and assignment. There is no need for a mode split step since the commodity movement estimates for rail, air, water, and/or pipeline will come directly from the Texas SAM. The primary objective within the urban model is to distribute the SAM internal truck commodity estimates, generate the additional internal truck commodity movements, and integrate the externally related truck commodity movements within the urban area.

The remainder of this chapter is organized to first present brief discussions of data availability, zone systems, and networks relative to the Texas SAM and those typically used in urban area travel demand models. Following these discussions are sections describing the individual steps in the model, i.e., generation, distribution, and assignment. These sections discuss the data requirements and recommended data sources for model implementation. The final section presents an overview that describes the entire modeling process and how the different steps are merged to produce either estimates of commodity flows or vehicle flows.

DATA

The data used in the Texas SAM for modeling freight consist of estimates of households, basic employment, retail employment, and service employment at the county level. The data used in most urban area travel demand models consist of estimates of households, basic employment, retail employment, and service employment at the TAZ level. There are some urban areas such as the HGA that use other categories of employment. Essentially, the model for estimating urban freight/commodities should utilize these data sources.

ZONE SYSTEMS

The Texas SAM uses two levels of zones. The one used in modeling freight includes each county as a zone (254 zones), counties in states outside Texas but bordering Texas are used as zones (142 zones), and 35 external stations are used to model commodity movements among Texas, the U.S., and international movements to Mexico, Canada, etc. The second level in the Texas SAM model uses 4600 internal zones within Texas. The freight modeling is done at the 431 zone level and the results disaggregated to the finer zone level for distribution and assignment. The zone systems in urban areas vary depending on the size of the area but in all cases includes more zones than used in the Texas SAM. External zones are also used to represent the external movements into, out of, and through the urban area. These typically represent transportation facilities at the border of the urban study area where movements may enter or leave the study

area. For example, the zone system used in the HGA includes over 2900 internal zones. The zone system in the Dallas Fort Worth area includes over 5000 internal zones. The integration of the Texas SAM freight estimates into the urban travel demand models requires a distribution of the estimates into the urban zone structure.

NETWORKS

The version of the Texas SAM at the time of this research included a highway and rail network. The level of detail for those networks was commensurate with the zone systems used in the modeling. For urban areas, the transportation network consists of the highway and street system within the urban area being modeled. It does not include rail.

GENERATION

The generation step modeling results in estimates of the quantity of each commodity being shipped or received at the zone level. The initial estimates of these quantities come from the Texas SAM at the county level. It should be noted that in the literature and documentation on freight/commodity models, reference is sometimes made to estimates of productions and attractions. For clarity, in this research, the terms shipping and receiving are used to represent the amounts of a commodity being shipped from an origin (i.e., zone) to a destination (i.e., zone) where the commodity is received. These terms are analogous to the terms productions and attractions but are felt to more accurately reflect what is being modeled.

The proposed generation model is comprised of two distinct parts. The first part deals with internal estimates of commodities and the second part deals with external related movements of commodities. Internal estimates are referred to as II estimates while external related movements are referred to as EI for external to internal, IE for internal to external, and EE for external to external (i.e., through movements).

Internal Estimates

The estimates of commodities being shipped and received internally within an urban area is proposed to be developed using the estimates generated by the Texas SAM and by a model developed using data collected within the urban area. The data generated by the Texas SAM is referred to as “top-down” estimates because it is generated from a statewide model and disaggregated into the urban level components for use in the urban model. The urban model is referred to as “bottom-up” estimates because it is generated from urban area data and estimated at the urban zone level.

It is important to note that the proposed model will concentrate on commercial vehicles used for freight/commodity movements. As Figure 4.1 shows, commercial vehicles that are used for providing services in the urban areas will not be part of the model because there is not sufficient information to be able to model service vehicle movements and these vehicles do not normally carry commodities.

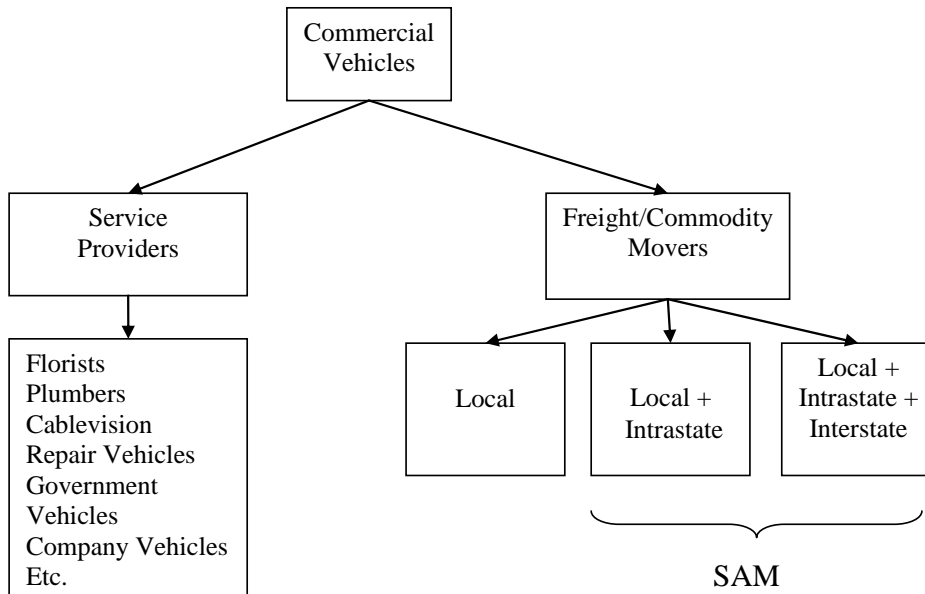


Figure 4.1. Commercial Vehicle Types.

“Top- Down” Phase

The “top-down” phase is proposed to first separate the Texas SAM commodity movements into the movements estimated to be made by trucks for the state. The county-to-county movements for an urban area would be identified. In some urban areas, these movements would involve multiple counties and in others, only one county may be involved. In situations where the urban area is located solely in a single county, the SAM estimates would be identified as intra-zonal estimates for the individual county. It is not proposed to use the finer zone estimates from SAM because those estimates have gone through a disaggregation procedure in SAM and it is not felt to be reasonable to disaggregate estimates that have already been disaggregated. It is considered more accurate to disaggregate the estimates that have been developed based on a calibrated model. The proposed model will use the same commodity groups developed for the Texas SAM as shown in Table 3.8.

The county-to-county estimates of commodity movements (in tons) will classify the tons of each commodity as being shipped from the county of origin and the tons of each commodity as being received by the county of destination. The commodity tons will be disaggregated to the urban zones within each county based on the number of employees in each zone. This disaggregation is a straightforward disaggregation procedure that proportionally splits the tons of each commodity being shipped and received according to the number of employees in each zone within the county of origin and the county of destination. The decision to use employment was based on the reasoning that these estimates are based on the statewide model and employment was felt to be a more accurate basis for allocating the tons of each commodity being shipped and received to the urban zones. Note that this procedure does not estimate the resulting commodity flows between the urban zones. These estimates will result from the distribution model after merging the SAM estimates and urban model estimates.

“Bottom-Up” Phase

The proposed “bottom-up” phase model is based on using part of the current method for estimating truck trips in urban areas in combination with data collected in commercial vehicle surveys in urban areas. The current method for estimating truck trips in urban areas uses a total estimate of truck (typically referred to as commercial vehicles) trips that are distributed to work place establishments based on a commercial vehicle trips per employee rate (referred to as a commercial vehicle attraction rate). These rates are stratified by employment type and area type. Table 4.1 shows an example of these rates. Area type referred to a measure of development intensity for each zone. The development intensity is based on a combination of employment and population within a zone and the size of the zone in acres. The number of commercial vehicle trips attracted to a zone would be estimated by multiplying the number of employees in the zone by the commercial vehicle trips per employee rate for that zone based on the employment type and the zone’s area type. The commercial vehicle trips produced in the zone are set equal to the number attracted to the zone by convention. Rates are also developed based on the number of households. This method does not provide any differentiation between freight/commodity carrying vehicles and service provider vehicles nor does it include any estimation of the type and/or amount of freight/commodity being transported.

Table 4.1. Commercial Vehicle Trip Rates for Laredo (52, 53, 54).

Area Type	Employment Type			Households ¹ (per household)
	Basic (per employee)	Retail (per employee)	Service (per employee)	
Central Business District	0.14	0.35	0.25	0.13
Urban	2.45	0.75	0.55	0.13
Suburban	2.55	0.85	1.10	0.13
Rural	6.95	0.96	1.26	0.13

¹Household rates developed from data in references 53 and 54.

As noted the method described in the previous paragraph does not differentiate between types of commercial vehicles or include any estimation of the amount or type of freight/commodity to be transported (if any). Part of this information may be estimated using data from the commercial vehicle surveys done in urban areas. These surveys collected data on the number, purpose, cargo, origin, and destination of trips made during a weekday by randomly selected commercial vehicles operating in the urban area. The driver was also asked to record the type of land use at the origin and destination of each trip. The data element not collected at the time of this research was the weight of the cargo being delivered or picked up. This information would have to be estimated based on the type of vehicle and secondary data on average vehicle loads. Surveyed vehicles were identified by the vehicle classification shown in Table 4.2 and by the vehicle’s gross vehicle weight. The trip purposes used in the survey are shown in Table 4.3 and the cargo codes and descriptions are shown in Table 4.4.

Table 4.2. Commercial Vehicle Survey Vehicle Classification Codes.

Code Number	Classification
1	Single Unit 2-axle (6 Wheels)
2	Single Unit 3-axle (10 Wheels)
3	Single Unit 4-axle (14 Wheels)
4	Semi (All Tractor Trailer Combinations)
5	Other

Table 4.3. Commercial Vehicle Survey Trip Purposes.

Code Number	Trip Purpose
1	Base location/Return to Base Location
2	Delivery
3	Pick-up
4	Vehicle Maintenance
5	Driver Needs
6	Other

Table 4.4. Commercial Vehicle Survey Cargo Codes.

Cargo Code	Cargo Description
1	Farm Products
8	Forest Products
9	Marine Products
10	Metals and Minerals
20	Food, Health, and Beauty Products
21	Tobacco Products
22	Textiles
26	Wood Products
27	Printed Matter
28	Chemical Products
29	Refined Petroleum or Coal Products
30	Rubber, Plastic, and Styrofoam Products
32	Clay, Concrete, Glass, or Stone
38	Manufactured Goods/Equipment
40	Wastes
41	Miscellaneous Shipments
49	Hazardous Materials
60	Unclassified Cargo
98	Unknown to Driver
99	Empty

To utilize the existing software TRIPCAL5 for generation, the urban freight/commodity model needed to be structured as either a rate model or a regression model. Since no data exist that would allow the development of a regression model, it was decided to use the commercial vehicle trip rates from the workplace survey and the commercial vehicle survey data to develop commodity rates that could be input into TRIPCAL5 and used with the existing zonal data to estimate the tons of commodity being shipped and received by zone. This formulation would produce results that could be input into the distribution step for estimating commodity flows between zones. To accomplish this, the following steps were required:

1. Establish an equivalency between the commodity groups being modeled in the Texas SAM and the commodity data collected in the commercial vehicle survey.
2. Process the commercial vehicle survey data to identify the trips that were shipping and/or receiving cargo based on the purpose of the trip.
3. Estimate the weight of the cargo being shipped and received by land use.
4. Develop the percent distribution of commercial vehicle trips by cargo being shipped and received including trips that the vehicle is empty by land use.
5. Develop the percent distribution of commercial vehicle trips where the cargo is actually being transferred when delivered or picked up by cargo type by land use.
6. Based on the origin and destination zones, compute the average trip length for each cargo type being transported.

By completing these steps, shipping and receiving rates (tons of commodity per employee or household) can be computed using the following equations.

$$\frac{W_{LAC}^s}{U_{LA}} = \frac{T_C^s}{V_C^s} \left(\frac{V_{LA}}{U_{LA}} \right) (P_{LC}^s) (M_{LC}^s) \quad (1)$$

Where:

- W_{LAC}^s = weight in tons of commodity C being shipped from land use L , area type A ;
- U_{LA} = unit for land use L and area type A , i.e., type of employment or households;
- T_C^s = tons of commodity C being shipped;
- V_C^s = number of vehicles carrying commodity C ;
- V_{LA} = vehicle trips to land use L and area type A ;
- P_{LC}^s = percentage of vehicles shipping commodity C from land use L ; and
- M_{LC}^s = of the vehicles shipping commodity C from land use L , this is the percentage that were actually transferring cargo.

$$\frac{W_{LAC}^r}{U_{LA}} = \frac{T_C^r}{V_C^r} \left(\frac{V_{LA}}{U_{LA}} \right) (P_{LC}^r) (M_{LC}^r) \quad (2)$$

Where:

- W_{LAC}^r = weight in tons of commodity C being received at land use L , area type A ;
- U_{LA} = unit for land use L and area type A , i.e., type of employment or households;
- T_C^r = tons of commodity C being received;
- V_C^r = number of vehicles carrying commodity C ;
- V_{LA}^r = vehicle trips to land use L and area type A ;
- P_{LC}^r = percentage of vehicles receiving commodity C at land use L ; and
- M_{LC}^r = of the vehicles receiving commodity C at land use L , this is the percentage that were actually transferring cargo.

Equations 1 and 2 provide shipping and receiving rates for each commodity group being modeled. These rates may be used to estimate the tons of commodities being shipped and received by transportation analysis zone. They do not, however, provide estimates of the number of empty and non-transfer trucks being produced and attracted by zone. In other words, in terms of vehicle movements, equations 1 and 2 only provide part of the answer. In developing the distribution of vehicles shipping/receiving commodities by land use type, the distribution includes the number of vehicles leaving and arriving empty by land use type. The empty vehicle shipping/production and receiving/attraction rates may be computed using the following equations.

$$\frac{E^s}{U_{LA}} = \left(\frac{V_{LA}}{U_{LA}} \right) P_{EL}^s \quad (3)$$

Where:

- E^s = empty vehicle shipping movements (i.e., productions);
- U_{LA} = unit for land use L and area type A , i.e., type of employment or households;
- V_{LA} = vehicle trips to land use L and area type A ; and
- P_{EL}^s = percentage of empty vehicles in shipping movement for land use L .

$$\frac{E^r}{U_{LA}} = \left(\frac{V_{LA}}{U_{LA}} \right) P_{EL}^r \quad (4)$$

Where:

- E^r = empty vehicle receiving movements (i.e., attractions);
- U_{LA} = unit for land use L and area type A , i.e., type of employment or households;
- V_{LA} = vehicle trips to land use L and area type A ; and
- P_{EL}^r = percentage of empty vehicles in receiving movement for land use L .

The last portion of travel represents the movements of trucks that are carrying cargo but not actually transferring the cargo. The rates representing those movements (i.e., truck productions and attractions) are computed using the following equations. Note that equation 5 simplifies to

its equivalent equation 6. Similarly equation 7 simplifies to equation 8. It should also be clear at this point that equations 1 through 8 are predicated on the truck trip rates developed by land use and area type from the urban area workplace surveys with the types of commodities, amounts, and empty/non-transfer vehicles being estimated using distributions from the commercial vehicle surveys.

$$\frac{N_{LAC}^s}{U_{LA}} = \frac{V_{LA}}{U_{LA}} - \left[\left(\frac{V_{LA}}{U_{LA}} \right) (P_{LC}^s)(M_{LC}^s) \right] - \left[\left(\frac{V_{LA}}{U_{LA}} \right) P_{EL}^s \right] \quad (5)$$

$$\frac{N_{LAC}^s}{U_{LA}} = \frac{V_{LA}}{U_{LA}} [1.0 - [(P_{LC}^s)(M_{LC}^s)] - [P_{EL}^s]] \quad (6)$$

Where:

- N_{LAC}^s = number of vehicles carrying commodity C from land use L and area type A making no transfer of cargo;
- U_{LA} = unit for land use L and area type A , i.e., type of employment or households;
- V_{LA} = vehicle trips to land use L and area type A ;
- P_{LC}^s = percentage of vehicles shipping commodity C from land use L ;
- M_{LC}^s = of the vehicles shipping commodity C from land use L , this is the percentage that were actually transferring cargo; and
- P_{EL}^s = percentage of empty vehicles in shipping movement for land use L .

$$\frac{N_{LAC}^r}{U_{LA}} = \frac{V_{LA}}{U_{LA}} - \left[\left(\frac{V_{LA}}{U_{LA}} \right) (P_{LC}^r)(M_{LC}^r) \right] - \left[\left(\frac{V_{LA}}{U_{LA}} \right) P_{EL}^r \right] \quad (7)$$

$$\frac{N_{LAC}^r}{U_{LA}} = \frac{V_{LA}}{U_{LA}} [1.0 - [(P_{LC}^r)(M_{LC}^r)] - [P_{EL}^r]] \quad (8)$$

Where:

- N_{LAC}^r = number of vehicles carrying commodity C to land use L and area type A making no transfer of cargo;
- U_{LA} = unit for land use L and area type A , i.e., type of employment or households
- V_{LA} = vehicle trips to land use L and area type A ;
- P_{LC}^r = percentage of vehicles receiving commodity C from land use L ;
- M_{LC}^r = of the vehicles receiving commodity C from land use L , this is the percentage that were actually transferring cargo;
- P_{EL}^r = percentage of empty vehicles in receiving movement for land use L .

The first step was to establish an equivalency between the commodity groups being modeled in the Texas SAM and the commodity data collected in commercial vehicle surveys. Table 4.5

shows that equivalency. It should be noted that the Texas SAM commodity group Raw Materials has been combined with Chemicals and Petroleum. This combination was done because in the commercial vehicle survey, the distinction between the raw materials group that contained metals and minerals to the chemical products and refined petroleum or coal products used in the survey was not clear. It was felt the vehicle drivers in completing the survey could code their cargo either way and it would be more accurate to combine the two groups for purposes of model development using the commercial vehicle survey data.

The second step in processing the data was to identify a trip as to shipping or receiving. If the purpose of the trip was delivery, the trip was classified as shipping for the origin and receiving at the destination. If the purpose of a trip was to pick up, the trip was identified as shipping at the destination end and receiving at the next destination if the next trip purpose was delivery. If the trip purpose was other than delivery or pick up and the vehicle was carrying a cargo, the trip was identified as a non-transfer trip. This process was tied to the third step of estimating the amount of cargo being shipped and/or received by making a number of assumptions. Since no data (at the time of this research) were collected on the weight of cargo being delivered or picked up, it was necessary to make some assumptions relative to the weight of cargo being transported initially and how much would be delivered and/or picked up. The assumptions were developed by establishing average loads by commodity and vehicle type. The commercial vehicle survey classified vehicles into four types: single unit two-axle, single unit three-axle, single unit four-axle, and tractor-trailer combination. While data were collected on the type of cargo being transported and the gross vehicle weight (GVW), no data were collected on the weight of the cargo. For this reason, it was necessary to use secondary sources and make some assumptions concerning the weight of the cargo being transported. Tables 4.6 and 4.7 present data from a draft technical memorandum on a commodity model specification study for the Florida Department of Transportation and a FHWA study. These data were used to develop the percentage gross vehicle weight load factors shown in Table 4.8.

Table 4.5. Equivalency between SAM Commodity Groups and Survey Classifications.

SAM Commodity Groups	Survey Cargo Classification
Agriculture	Farm Products
	Forest Products
	Marine Products
Raw Materials	Metals and Minerals
	Chemical Products
	Refined Petroleum or Coal Products
Food	Food, Health, and Beauty Products
	Tobacco Products
Textiles	Textiles
	Rubber, Plastic, and Styrofoam Products
Wood	Wood Products
	Printed Matter
Building Materials	Clay, Concrete, Glass, or Stone Products
Machinery	Manufactured Goods/Equipment
Miscellaneous	Wastes
	Miscellaneous Shipments
Secondary	Unclassified Cargo
Hazardous Materials	Hazardous Materials

Table 4.6. Florida Model Average Payloads.

Commodity	On-Road Average Payload (lbs.)	Average Payload in Pounds				
		< 50 Miles	50 – 100 Miles	100-200 Miles	200 – 500 Miles	300 + Miles
Agriculture	32,725	18,408	36,286	43,901	38,956	35,572
Minerals	41,637	41,237	35,000	42,138		46,000
Food Products	36,456	17,283	37,194	44,574	42,209	42,465
Non-Durable Manufacturing	17,358	7,155	10,105	36,208	12,441	29,579
Lumber	28,052	9,405	50,378	44,780	56,639	48,314
Paper	30,218	22,630	19,924	39,723	34,003	36,960
Chemicals	33,170	23,215	41,506	39,240	46,916	37,329
Petroleum Products	42,082	39,091	51,042	54,648	43,708	34,653
Durable Manufacturing	22,761	10,237	13,944	37,440	38,416	34,464
Concrete/Clay/Glass	36,931	31,647	40,617	39,934	45,413	44,802
Miscellaneous Freight	24,871	13,796	14,416	41,777	38,575	36,853
Non-Municipal Waste	25,081	20,565	34,060	32,295	43,132	42,066
Warehousing	18,137	18,039	13,068	47,820	6,685	23,125
Average	28,429	19,931	24,034	41,130	39,219	37,602

Table 4.7. Comprehensive Truck Size and Weight Payload.

Item	Single Unit		Semi-Trailer		Double Trailer			Triple Trailer	
	3	4	5	6	5	7	8	7	7
Gross Vehicle Weight (lbs.)	54,000	64,000	80,000	90,000	80,000	100,000	105,000	100,000	115,000
Tare (empty) (lbs.)	22,600	26,400	30,490	31,530	29,320	38,600	33,470	41,700	41,700
Payload (lbs.)	31,400	37,600	49,510	58,470	50,680	61,400	71,530	58,300	73,300

Table 4.8. Percent Gross Vehicle Weight Load Factors.

Index	Commodity Group	Average Load ¹ (Pounds)	2-Axle Vehicles		3-Axle	4-Axle	Semi-Tractor Trailer
			< 10,000 (% of GVW)	≥ 10,000 (% of GVW)			
1	Agriculture	18,408	10.0 %	10.0 %	15.0 %	20.0 %	20.4 %
2	Minerals, Chemicals, Petroleum	34,514	38.3 %	38.3 %	63.9 %	53.9 %	38.3%
3	Food Products	17,283	19.0 %	19.0 %	32.0 %	27.0 %	19.2 %
4	Textiles/Nondurable Manufacturing	7,155	10.0 %	10.0 %	15.0 %	11.2 %	8.0 %
5	Lumber Paper Products	16,018	17.0 %	17.0 %	29.7 %	25.0 %	17.8 %
6	Building Materials	31,647	10.0 %	10.0 %	20.0 %	20.0 %	35.2 %
7	Durable Manufacturing/Machinery	10,237	11.0 %	11.0 %	19.0 %	16.0 %	11.4 %
8	Wastes and Miscellaneous	17,181	19.0 %	19.0 %	31.6 %	26.8 %	19.1 %
9	Warehousing/Unclassified/Secondary	18,039	10.0 %	10.0 %	20.0 %	15.0 %	20.0 %
10	Hazardous Materials	**	21.0 %	21.0 %	35.1 %	29.6 %	21.0 %

¹ Source – Florida Urban Model Average Payloads used as basis for estimating average loads and percentage of gross vehicle weights. Percentages adjusted during model development.

** No data were available, average payload of 18,942 (the average of all other commodities) used and the percent GVW was assumed for two-axle vehicles.

There was not a one-to-one conversion between the commodity groups in Table 4.6 and those being used in this research. Some assumptions were made to equate the groups in Table 4.6 to those shown in Table 4.5. The average payloads were configured in terms of a percentage of GVW to ensure no vehicle could be estimated to carry more than its capacity. This configuration allowed the average payload to be based in part on both the commodity being transported and the vehicle classification. The average payloads for trips less than 50 miles were used to develop the percentages shown in Table 4.8. There were no data shown for two-axle vehicles so the computed percentages for semi-tractor trailers were assumed for those vehicles.

Table 4.9 presents some examples of vehicle trips taken from a commercial vehicle survey to illustrate the process of determining the shipping and receiving weights as well as those movements of vehicles where cargo was reported be carried but no transfer was made. These examples illustrate the assumptions made in analyzing the data relative to the weight of cargo being initially shipped and how the deliveries were assumed to be in equal amounts for sequential stops. If a vehicle left the base and made several deliveries (or even just one), it was assumed it was fully loaded relative to the percent of the vehicle’s gross vehicle weight based on the values in Table 4.8. The values shown in Table 4.9 are used for illustration purposes only.

Table 4.9. Examples of Commercial Vehicle Trips.

Vehicle	Trip Purpose		Cargo	Weight (lbs.)	
	Origin	Destination		Shipping	Receiving
1	Base	Pick Up	Empty	0	0
	Pick Up	Pick Up	Miscellaneous	3900	0
	Pick Up	Delivery	Miscellaneous	3900	7800
	Delivery	Driver Needs	Empty	0	0
	Driver Needs	Base	Empty	0	0
2	Base	Pick Up	Food, etc.	0	0
	Pick Up	Vehicle Maintenance	Food, etc.	8100	0
	Vehicle Maintenance	Delivery	Food, etc.	0	8100
	Delivery	Pick Up	Empty	0	0
	Pick Up	Delivery	Unclassified	8100	4050
	Delivery	Delivery	Unclassified	0	4050
	Delivery	Pick Up	Unclassified	0	0
	Pick Up	Base	Unclassified	8100	8100
3	Base	Delivery	Food, etc.	8100	1620
	Delivery	Delivery	Food, etc.	0	1620
	Delivery	Delivery	Food, etc.	0	1620
	Delivery	Delivery	Food, etc.	0	1620
	Delivery	Delivery	Food, etc.	0	1620
	Delivery	Pick Up	Food, etc.	0	0
	Pick Up	Pick Up	Food, etc.	4050	0
	Pick Up	Base	Empty	4050	8100

In Table 4.9, vehicle 1 left the base location and traveled to its first location. Based on the vehicle classification and gross vehicle weight, the fully loaded weight is assumed to be 7800 pounds. The purpose recorded is to pick up cargo. The cargo is recorded as empty for this first trip and the shipping and receiving weights are zero. At the vehicle’s first stop, a cargo is picked up. Since the vehicle will make two pick ups before any delivery, it is assumed that half its load is picked up at the first stop and half is picked up at its second stop. The shipping weight for the second trip is 3,900 pounds and the receiving weight is zero because no cargo is delivered but cargo is picked up. The third trip, the shipping weight is 3,900 pounds (half the full load is picked up at the second stop) and the receiving weight is 7,800 pounds. Since only one delivery is recorded, the assumption is made the entire load is delivered at that location. The last two trips made by this vehicle were empty and no cargo was delivered or picked up.

Vehicle 2 in Table 4.9 left the base location and traveled to its first location. Based on its vehicle classification and gross vehicle weight, the fully loaded weight is assumed to be 8100 pounds. The trip purpose for the first trip is to pick up cargo but the vehicle is recorded as carrying food, etc. This example illustrates one of the difficulties in analyzing the data in terms of interpretation as to what the driver is recording. In this case, the driver was likely recording the type of cargo he was in route to pick up. The shipping and receiving weights for the first trip were identified as zero. The second trip was from the pick up location to a location for the purpose of vehicle maintenance. Here the shipping weight was assumed to be the full load for the vehicle and the receiving weight was zero since no delivery was made. The third trip was from the vehicle maintenance location to a delivery so the shipping weight was zero and the receiving weight was 8100 pounds. These two trips illustrate situations (shipping and receiving) where cargo was being carried but no transfer was made.

The examples in Table 4.9 illustrate the process of data analysis and some of the situations in the data where assumptions had to be made. It is also necessary to process the data and remove all vehicles that made no deliveries and/or pick ups. These vehicles are assumed to be service vehicles and not normally involved in cargo transport (see Figure 4.1). Much of the analysis illustrated in Table 4.9 will be simplified if future commercial vehicle surveys collect data on the weights of cargo being delivered and picked up. An additional improvement in the data collection may be accomplished by identifying vehicles as to cargo transport or commercial service vehicles.

The results of the steps previously discussed will be shipping and receiving rates (i.e., tons of commodity) for each commodity group for employment and households stratified by area type. These rates may be input to TxDOT's generation software, TRIPCAL5, and used to produce zonal estimates of each commodity being shipped and received. The TRIPCAL5 setup required for this is a cross-classification model for both production (shipping) and attractions (receiving). Each commodity group is modeled as a trip purpose. Chapter 5 shows examples of this setup, which contains an example of the modeling applications.

Special Generators

The proposed model for developing internal estimates of commodities being shipped and received by zone within an urban area represents data for trucks only. It is recognized that commodities move into, out of, and through urban areas by other modes such as rail, water, air, and pipelines. Modeling within urban areas, however, is limited to trucks by virtue of the fact that trucks are recognized as the mode used for final distributions within an urban area. To incorporate the impact that commodities movements by other modes have within an urban area, it is proposed to establish specific special generator categories that represent those unique facilities where commodities may be exchanged between modes, especially trucks. Estimates of commodity movements by truck for these unique facilities will be developed exogenously to the generation model and input directly. This procedure does require the MPO within each urban area to identify these facilities and use either the default rates provided in this research or perform special data collection surveys to obtain specific estimates of commodity movements from these facilities within their urban area.

Special generator examinations provide information on those unique land uses with special trip generating characteristics not adequately reflected by normal trip attraction rates (55). Freight facilities classified as special generators include:

- Rail Intermodal Facilities,
- Truck Terminals,
- Airport Terminals,
- Pipeline Terminals,
- Port Facilities, and
- Container Port Terminals.

This research focused on the movement of trucks at each facility. For the pipeline terminals, only tank farms were considered. These pipeline terminals consist of a direct connection between trucks and pipelines where refined product is transferred from pipeline to trucks for final distribution. The port shipping rates were developed only for the truck portion of the tonnage through the facilities. The truck terminals examined are those focused on packages and small freight, such as terminals operated by Federal Express (FedEx), United Parcel Service (UPS), and the United States Postal Service (USPS).

Available Information for Special Generator Rates

During the course of developing the special generator shipping rates, many data sources were examined. A list of a portion of these sources is listed below, including a few details regarding each data source.

National Transportation Atlas Database 2003 (66). Developed by the Bureau of Transportation Statistics (BTS). The database contains the following:

- Intermodal Terminal Facilities with the following attributes:
 - Terminal name
 - Location: City, State, ZIP
 - Terminal type: Truck, Rail, Port or Air
 - Modal connections
- Ports with the following attributes:
 - Name, Operator, Owner, Contact information
 - Location
 - Purpose of port facility
 - Railway connection
 - Commodity code (4 fields)

Texas or Houston-Specific Sources. The following are brief descriptions of sources and documents examined to identify data that were applicable in the development of commodity shipping and receiving rates.

- Houston Intermodal Facility Inventory (62) done for the Houston-Galveston Area Council (HGAC) in January 2000. Inventory designed to identify regionally significant intermodal terminals eligible for National Highway System Connector funding. Consists of data sheets filled out by facility representatives. Noteworthy attributes:
 - General facility information
 - Type
 - Name
 - Size
 - Contact
 - Facility operational characteristics
 - Freight Type
 - Freight Volume
 - Inbound and Outbound Modes of Freight Movement

- Houston Intermodal Facility Inventory Geographic Information System (GIS) Database (68) developed for the HGAC in 1999. Noteworthy attributes:
 - Facility name
 - Address
 - Type – Connecting modes
 - Primary Criteria – i.e., number of trucks per day

- Development of Special Generator Trips for Ports (56). A technical memorandum done at the HGAC dated January 21, 2000. This memorandum documents the truck trip rates developed for fifteen different facilities located at the Ports of Houston, Galveston, and Freeport. Noteworthy data:
 - Facility name
 - Total tonnage per year
 - Truck tonnage per year

- Airport Statistics monthly reports published by the Houston Airport System (69). Monthly reports identify airport activities including the air freight tons by landings and departures.

- Texas Pipeline Intermodal Connections GIS Database (57) developed by the Texas Transportation Institute in 2001 as part of a TxDOT research project 0-1858. Noteworthy attributes:
 - Name, Operator, Owner, Address
 - Modes connecting with pipeline facility: Truck, Rail, Marine
 - Commodity Type – Description
 - Commodity Volume – Description

- Texas Statewide Transportation Plan and Texas Rail System Plan (72, 73). Both plans include descriptions of the port and intermodal facilities located in Texas.

- Research report about containerized freight movement in Texas (65) done at the Center for Transportation Research in Austin, July 2003. This research project analyzed how containers move through the Texas ports and between Texas and Mexico. The container port at Houston was specifically analyzed along with several rail intermodal terminals around the state.
- Final environmental impact studies (EIS) for the Port of Houston Bayport (71) and the Texas City Shoal Point Container Terminals (70). Each EIS utilized HGAC's Emme2 model to estimate effects on roadway network with inclusion of additional truck movements to and from new container terminals. Forecasted for 2005, 2015, and 2025.

Other Identified Resources. The following are brief descriptions of other sources identified with relevant data for use in developing commodity rates.

- New York Metropolitan Transportation Council – Multiple reports providing details related to freight facilities in the New York metropolitan region. These included a freight facilities and system inventory done in September 2000 (58) and updated in September 1995 (59). These inventories included data on physical and operational characteristics for truck, rail, marine, and air facilities. Noteworthy attributes include:
 - Facility size
 - Number of employees
 - Truck trips
 - Cargo volume

A truck terminals and warehouses survey (60) was done in February 2001 that collected data on the physical and operational characteristics for truck and warehouse facilities. Noteworthy attributes include:

- Facility size
 - Number of employees
 - Truck trips
 - Cargo volume
- The National Cooperative Highway Research Program (NCHRP) funded a synthesis on truck trip generation data (55) in 2001. This document analyzed various practices in evaluating truck trip generation data, including a review of available data sources and documentation of the current state of the practice.
 - A publication on the characteristics of urban freight systems (61) by the Federal Highway Administration in 1995 presents a thorough review of data and information pertaining to urban good movements and freight planning. It contains several sections related to truck movements and trip rates, along with sections related to rail intermodal terminals, air cargo, and ports.

Special Generator Rates

Special generator rates, in terms of tons per employee, were calculated for six different types of generators. Table 4.10 presents the summary of the rates and the inbound (received) and outbound (shipped) distribution that was calculated. The numbers represent only the truck portion of the commodity volume at the facilities.

Table 4.10. Truck Commodity Generation Rates by Facility Type.

Special Generator	Tons per Employee	% Shipped (outbound)	% Received (inbound)
Rail Intermodal	162.710	50	50
Truck Terminal	1.410	50	50
Air Terminal	0.108	50	50
Pipeline Terminal	426.170	100	-
Port Terminal	2.570	50	50
Container Port	37.200	50	50

The rates were obtained from various sources and the inbound and outbound split was derived from the HGAC Intermodal Facility Inventory (62). All the splits were approximately distributed evenly in each direction, with the exception of the pipeline terminals. As stated previously, these terminals represent locations where refined products are transferred from pipeline to trucks for final distribution.

Table 4.11 summarizes rates by commodity group. The variety of commodities handled and identified at ports allows for a dissemination of the rates by commodity groups. The pipeline facilities only handle chemical or petroleum products, whereas, container and parcel shipments through the rail, truck, air, and container terminals do not provide a commodity-specific breakdown. The port rates were divided by the percent of the total tonnage shipped and received for each commodity group, according to the commodities identified in the HGAC Intermodal Facility Inventory (62).

Table 4.11. Shipping and Receiving Rates by Commodity Group (Tons per Employee).

Shipping (Outbound) Rates						
Special Generator	1. Agriculture	2. Raw Materials	6. Chemicals, Petroleum	7. Building Materials	8. Machinery	9. Miscellaneous
Rail	No Data	No Data	No Data	No Data	No Data	81.355
Truck	No Data	No Data	No Data	No Data	No Data	0.705
Air	No Data	No Data	No Data	No Data	No Data	0.054
Pipeline	No Data	No Data	426.170	No Data	No Data	No Data
Port	0.018	0.363	0.550	0.264	0.003	0.087
Container Port	No Data	No Data	No Data	No Data	No Data	18.600
Receiving (Inbound) Rates						
Special Generator	1. Agriculture	2. Raw Materials	6. Chemicals, Petroleum	7. Building Materials	8. Machinery	9. Miscellaneous
Rail	No Data	No Data	No Data	No Data	No Data	81.355
Truck	No Data	No Data	No Data	No Data	No Data	0.705
Air	No Data	No Data	No Data	No Data	No Data	0.054
Pipeline	No Data	No Data	No Data	No Data	No Data	No Data
Port	0.022	0.490	0.661	No Data	0.004	0.109
Container Port	No Data	No Data	No Data	No Data	No Data	18.600

Specific Facility Rates

This section provides further discussion and the calculations for each special generator. Within each section, the data sources utilized for the calculations are discussed, along with any data conversion factors utilized during data preparation. In general, multiple data sources were utilized to calculate the special generator rates. The HGAC intermodal facility inventory (62) provided valuable information related to each facility including volumes, facility size, and mode share. However, there were no survey components related to employment at each facility to develop the tons per employee rate. The 1998 basic employment data provided by HGAC offered limited matches or questionable employment data in most cases. A few of the employment values were utilized in the pipeline terminal calculations.

The New York Metropolitan Council’s freight facilities and system inventory (58,59) done in 1995 and 2000, provide the most details regarding air, rail, water, and truck terminals. The truck terminals and warehouse survey (60) done in 2001, provides overlapping data for some facilities and data for additional facilities. Both resources provide facility volume, size, and employment levels. These resources were used extensively to characterize special generator rates by facility type.

An email survey was sent to the contacts listed in the HGAC intermodal facility inventory. Only one establishment responded with information. A representative from Intercontinental Terminals provided data specific to their pipeline terminal located in Houston.

In most cases, the data required conversions from the provided data source into daily tons. Conversion of the data were done utilizing conversion rates mostly from the HGAC intermodal facility inventory (62) and the characteristics of urban freight systems (61). Yearly totals were divided by 365 days in most cases.

In addition to the tons per employee rates utilized for this project, a tons per acre rate calculation was also developed. This measure was identified as a usable metric in several sources.

Rail Intermodal

Rail intermodal terminals typically reside within the urban areas in Texas. As space limitations for expansion at existing facilities develop over time and the movement of goods in container grows, additional terminals may be constructed outside the urban areas where enough land is available to construct new, advanced terminals. This is already the case in Dallas, where Union Pacific is constructing a new yard located in Wilmer and Hutchins, approximately 15 miles south of Dallas.

Currently, there are approximately 15 rail intermodal facilities in Texas, with three of those located in Houston. Container traffic in Houston travels through either the two Union Pacific Railroad facilities (Englewood & Settegast) or the Burlington Northern Santa Fe (BNSF) Railway facility next to Hobby Airport in south Houston. Most of the containers through these yards are considered domestic, whereas container ports handle international containers.

For this calculation, volume and employment levels were provided by interviews with BNSF Railway (Gail Seaman, Manager of Hub Operations, Business Unit Operations & Support, Houston, Texas, interviewed on November 19, 2002) and industry news articles (63,64) discussing newly created intermodal yards in the Chicago region. Conversion rates from number of lifts to daily tons were necessary to complete the calculations. The calculated tons per employee rate equals 162.71 for rail intermodal terminals. Table 4.12 presents the data utilized for rail intermodal and the resulting rate.

Table 4.12. Rail Intermodal Facility.

Rail Intermodal Facility	Size (acres)	Employees	Movements	Daily Lifts	Daily Tons	Tons per Acre	Tons per Employee
Hou - BNSF Pearland*	83	65	12,000 lifts per month	395	7,496	90	115
Hou- BNSF BC*		10	31,447 lifts per year	86	1,637		164
Chic - CSX 59th St. (63)	132	70	300,000 lifts per year	822	15,616	118	223
Chic - BNSF LP (64)		140	400,000 lifts per year	1,096	20,822		149
Notes:					Mean	104.309	162.710
1 Lift = 1 Unit					Median	104.309	156.212
1 Unit = 1.9 TEU (61)					Minimum	90.312	115.321
1 TEU = 10 Tons (62)					Maximum	118.306	223.092
*Interview with Gail Seaman, BNSF Railway							

Truck Terminals

The truck terminals addressed in this research project mainly consist of parcel and postal establishments, such as those operated by FedEx or UPS. These facilities are clearly presented in the New York documents (58, 59, 60). As shown in Table 4.13, the tons per employee rate for truck terminals is 1.41.

Table 4.13. Truck Terminals (58, 59, 60).

Truck Terminal	Operator	Size (acres)	Employees	Daily Tons	Tons per Acre	Tons per Employee
Queens Processing and Distribution Center	USPS	24.1	2000	4800	199.17	2.40
Mid-Island Processing and Distribution Center	USPS	40	2000	275	6.88	0.14
Morgan General Mail Facility	USPS	10	4872	3350	335.00	0.69
U.S. Postal Service (USPS) Airport Mail Center at JFK	USPS	27	2200	7600	281.48	3.45
UPS Laurelton	UPS	8	452	50	6.25	0.11
UPS Maspeth Hub	UPS	20	1590	300	15.00	0.19
UPS/43 Street Hub	UPS	4	2230	2250	562.50	1.01
UPS/Melville Hub	UPS	15	722	1260	84.00	1.75
UPS/Nassau Hub	UPS	20	980	2500	125.00	2.55
UPS/Foster Ave	UPS	10	600	1000	100.00	1.67
UPS Suffolk Hub	UPS	15	490	750	50.00	1.53
FedEx	JFK Hub	50	NA	100	2.00	
FedEx	EWR Hub	100	NA	500	5.00	
				<i>Mean</i>	<i>136.33</i>	<i>1.41</i>
				<i>Median</i>	<i>84.00</i>	<i>1.53</i>
				<i>Minimum</i>	<i>2.00</i>	<i>0.11</i>
				<i>Maximum</i>	<i>562.50</i>	<i>3.45</i>

Air Terminals

Air freight is the fastest growing freight sector. Shipments moved by air are typically small, high-valued, and time sensitive in nature. The major airports continue to expand their terminals to accommodate the fast growing air freight levels. Table 4.14 contains the air freight terminal rates. The recommended rate for air terminals is 0.11 tons per employee.

Table 4.14. Air Terminals (59).

Airport Name	Size (acres)	Employees	Annual Tons	Daily Tons	Tons per Acre	Tons per Employee
JFK	4,938	42,000	1,837,713	5034.83	1.020	0.120
La Guardia	680	9000	92,735	254.07	0.374	0.028
EWR	2,027	18,000	1,150,601	3152.33	1.555	0.175
				<i>Mean</i>	<i>0.983</i>	<i>0.108</i>
				<i>Median</i>	<i>1.020</i>	<i>0.120</i>
				<i>Minimum</i>	<i>0.374</i>	<i>0.028</i>
				<i>Maximum</i>	<i>1.555</i>	<i>0.175</i>

Pipeline Terminals

Pipeline terminals in the state of Texas were identified in previous research (57) done for TxDOT. The research goals were to better understand pipeline terminal operations and the effects on the Texas highway system. As part of that research project, 126 facilities were identified as interconnecting between pipelines and other modes. Of those, 43 pipeline tank farms, where there is only a truck-pipeline connection, were identified (57). Typically, trucks loading with refined products at these locations are destined for gas stations populated throughout urban areas.

The data utilized for this calculation comes from several data sources including the HGAC intermodal facility inventory (62), HGAC 1998 basic employment data, the New York Metropolitan Transportation Council (58, 59, 60), and an email survey of Intercontinental Terminal, Inc. The pipeline terminal rate, as shown in Table 4.15, is 426.17 tons per employee. Pipelines carry the inbound shipments and the trucks transport the refined products to the final destination.

Table 4.15. Pipeline Terminals (58,59,60,62).

Pipeline Terminal	Size (acres)	Employees	Volume	Daily Tons	Tons per Acre	Tons per Employee
GATX*	150	6	43 million tons per year	5890.4	39.27	981.74
Phillips*	61.6	16	250 trucks per day	7500.0	121.75	468.75
Motiva*	28	8	350,000,000 gallons per year	3261.6	116.48	407.70
Intercontinental**	265	182	63 trucks per day	1890.0	7.13	10.38
Chevron*	80	15	400,000,000 gallons per year	3727.5	46.59	248.50
CITGO*	9	4	121,000,000 gallons per year (250 days)	1646.3	182.92	411.56
NY Tosco***	10	11	5,000 tons per day	5000.0	500.00	454.55
				Mean	144.88	426.17
				Median	116.48	411.56
				Minimum	7.13	10.38
				Maximum	500.00	981.74

* Traffic Engineers Inc. and LKC Consulting Services (62)

** E-mail from Intercontinental Terminal Inc., April 2005

*** Harbowska, M., Truck Terminals and Warehouse Survey Results, 2001 (60)

Port Facilities

Port facilities are a very diverse conglomeration of many individual facilities, some publicly operated and some privately operated, typically over a large land area. The diverse commodities handled through the ports are usually handled through specialized facilities, such as ones that might only handle palletized freight, refrigerated fruits, or grains. For the 25-mile-long Port of Houston, public facilities handle approximately 15 percent of the commodities, while over 150 privately operated companies handle the remaining 85 percent (67).

The diversity of commodities and modal split created added complexities different than the other special generators examined. The sources of data utilized include the New York Metropolitan Council freight facilities and system inventory (59), HGAC intermodal facility inventory (62),

and HGAC development of special generator trips for ports (56). The major challenge was identifying the tons associated with truck movements from the total tonnage. The technical memorandum developed by HGAC to develop port trip rates does segregate the truck tonnage from the total. However, facility employment data were not available for the Houston port facilities. The New York inventory provided a means to calculate the average employees per acre, which then was applied to the Houston data to estimate facility employment based on size. Table 4.16 displays the results of the port special generator rate. The recommended rate is 2.57 tons per employee.

In order to develop the rate breakdown by commodity, the port rate was divided by the percent of the total tonnage shipped and received for each commodity group, according to the commodities identified in the HGAC intermodal facility inventory (62). It should be noted that the port facilities handling building material indicated receiving all inbound shipments via marine vessel and shipping outbound shipments via truck and other modes. These facilities were primarily cement companies.

Table 4.16. Port Terminal.

Facility	Acres	Employees	Total Annual Tons	Annual Truck Tons	Daily Truck Tons	Tons per Acre	Tons per Employee
Turning Basin - South	80	190	2,775,000	277,500	760	9.50	4.01
Turning Basin - North	300	711	5,262,908	2,105,163	5768	19.23	8.11
Public Elevator	40	95	1,162,900	17,444	48	1.19	0.50
Bulk Materials Plant	100	237	2,246,239	224,624	615	6.15	2.60
Woodhouse Terminal	100	237	418,954	196,908	539	5.39	2.28
Bayport	935	2216	4,900,000	245,000	671	0.72	0.30
Jacintoport Terminal	125	296	400,000	20,000	55	0.44	0.18
Notes:					<i>Mean</i>	6.09	2.57
Employees = Acres x 2.37 (59)					<i>Median</i>	5.39	2.28
					<i>Minimum</i>	0.44	0.18
					<i>Maximum</i>	19.23	8.11

Container Port Terminals

Container ports are special port facilities only handling intermodal containers. Because of their significance and identification as a separate special generator in several literature sources, it was decided to handle container ports as a separate facility from the port terminals. Texas has only one major container port terminal, which is located at Barbours Cut in the Port of Houston. The Port of Houston also has plans to expand container operations at a new facility along the ship channel. Minor container operations exist at several other Texas ports. Some of these ports also have plans to expand intermodal container terminals. The container port special generator rate for this project is 37.20 tons per employee, as displayed in Table 4.17.

Table 4.17. Container Terminal (59,62).

Container Port Facility	Size (acres)	Employees	Volume (20-Foot Container Equivalent Unit [TEU]/yr)	Daily Tons	Tons per Acre	Tons per Employee
Maher Tripoli	243	400	380,000	10,411	42.8	26.0
Universal-Maersk	153	500	350,000	9,589	62.7	19.2
Sea-Land Marine	266	600	390,000	10,685	40.2	17.8
Maher Fleet Street	195	450	400,000	10,959	56.2	24.4
Global Marine	100	50	180,000	4,932	49.3	98.6
				<i>Mean</i>	<i>50.24</i>	<i>37.20</i>
				<i>Median</i>	<i>49.32</i>	<i>24.35</i>
				<i>Minimum</i>	<i>40.17</i>	<i>17.81</i>
				<i>Maximum</i>	<i>62.67</i>	<i>98.63</i>

External Estimates

The generation of external related estimates of commodities for an urban area is in some respects simpler than the estimation of internal urban estimates and in some respects, more complex because of the steps involved. The proposed model used the Texas SAM estimates of commodity movements into, out of, and through urban areas as the basis for these data. It is assumed that SAM produces the best estimates by virtue of its regional, statewide, and national basis and the resulting movements into, out of, and through urban areas. The complexity in this assumption is the integration of these movements into the urban modeling framework.

The Texas SAM produces estimates of commodity flows for 11 commodity groups. Based on the urban model development discussed previously, two of these commodity groups have been combined and the proposed model is now for 10 commodity groups. The following steps are necessary to incorporate the external movements generated by SAM into the proposed urban modeling system.

1. Run SAM and build a file containing the zone-to-zone commodity movements by truck for the entire state.
2. Run SAM and assign the commodity movements by truck to the highway and street system.
3. Identify the SAM network links that correspond to the urban area external stations.
4. Run the critical link routine in TRANSCAD for each link corresponding to the urban area external stations. The critical link routine identifies the origin and destination zones and amount of each commodity movement over the links that correspond to the urban area external station.
5. Process the results of the critical link runs to determine the amount of each commodity moving between each external station to/from the counties within the urban area being modeled.
6. At this point, the modeler has two options. The first is to disaggregate the movements from each external station to/from the urban area zones based on the urban area zonal

employment. This disaggregation builds a movement table for each external station to the urban zones for each commodity moving into and out of the study area. The second option is to use data (if available) from the urban area external station survey to distribute the commodities moving into and out of the study area. This is the option recommended if the urban area has an external survey because the external survey includes commercial vehicles and provides a more accurate pattern of distribution for each external station than will be achieved by distributing to the urban zone system based on the zonal employment.

7. Process the results of the critical link runs to determine the amount of each commodity moving between all external stations, i.e., build the through movement tables for each commodity. It is recommended that data from the urban area external station survey be used as the basis for estimating the external through movements in the urban area. The SAM provides the amount of commodities moving into/out of the urban area but the data from the external station survey provide more accurate patterns of where those movements are going.

The results are estimates of commodity movements between the urban area external stations and the urban area zones. It should be noted that a large number of files are generated in this process. This process will be illustrated in Chapter 5 when the steps and results are shown for applying this model.

DISTRIBUTION

The second step in the proposed commodity model is that of distribution. For this step, the model proposed to be used is the Atom2 gravity model currently used by TxDOT in modeling passenger movements. The internal estimates of commodities with the results of the special generator estimates yield estimates of commodities being shipped and received at each traffic analysis zone. It is proposed to use the average trip lengths obtained from the analysis of the commercial vehicle survey data as input to the distribution model. The model will be constrained to produce the input tons of commodities being shipped and received at each zone and match the average trip length for each commodity. The Atom2 model will develop friction factors for use in forecast modeling.

It should be noted that it may be unreasonable to use the average trip length for each commodity based on the commercial vehicle survey. The commercial vehicle surveys only collect data for about 500 vehicles in each urban area. With ten commodity groups, the number of observed trips for some commodities may be too sparse to achieve a reasonable average trip length. If such is the case, then it is recommended the average trip length for all commodities be used in developing the friction factors and distributing the commodities.

It will not be necessary to distribute the external related estimates of commodity movements since these estimates are developed from the SAM and disaggregated to the urban zones. It will be necessary to combine the individual internal movement tables for each commodity with the external movement tables prior to assignment.

ASSIGNMENT

The final step in the modeling process is the assignment. The modeler has a choice to either assign commodities or trucks. In most cases, it is anticipated the modeler will assign trucks. Prior to running the assignment model, it will be necessary to convert the commodity movements to truck movements. The average load factors obtained in the analysis of the commercial vehicle survey should be used to convert the tons of commodity movements to truck movements prior to assignment. The resulting internal truck trip tables should be merged (i.e., summed) with the truck trip tables for empty vehicles and for vehicles that are not transferring cargo prior to being assigned. The recommended assignment is a minimum time path (i.e., all or nothing) assignment. This is consistent with what was found in the literature review with practice in both statewide and urban area modeling.

CALIBRATION

Since the modeling steps and procedures are essentially the same as those used in travel demand modeling, the calibration of the model should be similar to that for passenger modeling. It is noted, however, that passenger modeling has more data available for calibration whereas little or no data are available for calibration of commodity movements. There are some data available for calibration of truck estimates but these are limited to regional estimates of truck vehicle miles of travel (VMT) and some truck counts within urban areas. This is one area that specific recommendations will be made that will provide better information for calibration in future modeling applications.

SUMMARY

The proposed model structure presented in this chapter accomplishes several objectives. First, it integrates the internal estimates of commodity flows developed from the Texas SAM into the urban travel demand modeling structure. Second, it produces an urban modeling system that independently models commodity movements, empty truck movements, and truck movements carrying commodities but not transferring cargo. The proposed modeling system is consistent and builds upon the use of travel surveys in urban areas and the current software programs used by modelers for TxDOT. These programs facilitate the integration of the proposed model into the urban travel demand modeling process currently used by TxDOT.

CHAPTER 5 – MODEL APPLICATION EXAMPLE

The model structure presented in Chapter 4 is a combination of the use of Texas SAM results and the application of independent models to estimate commodity and vehicle movements within urban areas. This chapter presents an application of the model structure as proposed in Chapter 4. This serves two purposes: 1) it illustrates all of the steps involved in the modeling application and 2) it demonstrates the reasonableness of the estimates that are produced in the model.

The HGA was selected for this demonstration. The most compelling reasons for this selection were the following:

- The HGA is a major center for commodity movements.
- The HGA offers a more rigorous test of the use of special generators in estimating commodity movements because it includes a major port, pipeline terminals, etc.
- The HGA offers modeling challenges that are not likely to be faced in the majority of other urban areas in Texas.
- The HGA has an ongoing travel demand modeling staff that could provide assistance in providing the transportation network, zonal data, etc. for use in the proposed commodity model.
- A full set of travel surveys were conducted in the HGA in 1995 that included an external station survey, workplace survey, and commercial vehicle survey.

HOUSTON-GALVESTON AREA

The HGA currently being modeled consists of an eight-county area. The counties included in that area are Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller. The Texas SAM base year model is for 1998. The travel surveys done in the Houston-Galveston area were in 1995 and the zonal socio-demographic data for the Houston-Galveston travel demand model is 1998. The number of zones in the HGA is 2,954. The travel demand model for the HGA is different from the majority of urban areas in Texas because of the number of employment categories used in the model. Houston uses six employment categories, industrial, retail, medical, office, education, and government. This means that the application of the proposed commodity model in this region will be different from the application that would be expected in other urban areas. In terms of demonstrating the model application and its results, this is not expected to pose a problem and will be addressed in Chapter 6 under recommendations.

“TOP-DOWN” MODEL APPLICATION

The “top-down” portion of the proposed commodity model is based on the commodity movements by truck estimated in the Texas SAM for the eight-county HGAC study area. The 1998 estimates of commodity movements were obtained from TxDOT’s, Transportation Planning and Programming (TPP) Division for the entire state. These data included intrastate movements and movements between counties in Texas and areas outside the state. The first step was to identify the commodity movements between the counties in the HGA (intra-urban

movements). The Texas SAM commodity movements are represented in a tabular form with a table for each commodity group. Each table contains the estimated movements between all zones. The total number of zones was 431. This total included 254 internal zones in Texas (one for each county), 45 zones around the perimeter of the state (counties in adjacent states that bordered Texas), and 132 external stations. When these data were received, it was noted that the commodity movements by truck were estimated for only nine commodity groups:

- agriculture,
- raw materials,
- food,
- textiles,
- wood,
- chemicals and petroleum,
- building materials,
- machinery, and
- secondary.

The proposed model for urban areas combines the chemical and petroleum commodity group with raw materials. This model reduced the number of commodity groups from the Texas SAM to eight with no estimates for miscellaneous and hazardous materials. These groups are modeled in the “bottom up” portion of the urban model.

The data from the SAM was put into a comma delimited format containing the following data:

- origin zone,
- destination zone,
- tons of agriculture moving from origin to destination,
- tons of raw materials moving from origin to destination,
- tons of food moving from origin to destination,
- tons of textiles moving from origin to destination,
- tons of wood moving from origin to destination,
- tons of chemicals and petroleum moving from origin to destination,
- tons of building materials moving from origin to destination,
- tons of machinery moving from origin to destination, and
- tons of secondary cargo moving from origin to destination.

The reader may refer to Table 3.3 for definitions on the types of commodities included in each group. A GISDK program was written to read the comma delimited file from the SAM. The program also requires two other data files as input, the DA1 socioeconomic data file and an equivalency file that identifies the urban zones that lie within the SAM zones (i.e., counties in the urban area). The DA1 data file is the same as that used for modeling passenger movements in TRIPCAL5. The format for that file is contained in Reference 74. The program code and documentation description are contained in Appendix B. The output from this program is data files containing estimates of the tons of commodity being shipped and received for each zone in the urban area. The format for these files is the same as the output files from TRIPCAL5 used in passenger modeling.

Table 5.1 through Table 5.8 contain estimates of commodity movements by SAM zone (i.e., county) for the HGA. These estimates are annual tons. These estimates were disaggregated to the 2,954 urban zones in the Houston Galveston region using the Commodity Disaggregation Program contained in Appendix B. For use in the urban commodity models, these estimates were converted to daily estimates by dividing by 365. This is the same convention practiced in the Texas SAM modeling procedures. The estimated annual tons of commodities moving internally in the HGA are 28,091,165. The estimated tons moving on a daily basis are 76,962.

Table 5.1. Agriculture Movements for HGA (Annual Tons).

Origin County	Destination County								Totals
	Brazoria	Chambers	Fort Bend	Galveston	Harris	Liberty	Montgomery	Waller	
Brazoria	0	0	0	0	17,660	87	0	0	17,747
Chambers	0	0	0	0	0	0	0	0	0
Fort Bend	0	0	0	0	0	0	0	0	0
Galveston	0	0	0	0	9318	43	0	0	9361
Harris	0	0	0	0	3,663	17	0	0	3,680
Liberty	0	0	0	0	0	0	0	0	0
Montgomery	0	0	0	0	0	0	0	0	0
Waller	0	0	0	0	288	0	0	0	288
Totals	0	0	0	0	30,929	147	0	0	31,076

Table 5.2. Raw Material Movements for HGA (Annual Tons).

Origin County	Destination County								Totals
	Brazoria	Chambers	Fort Bend	Galveston	Harris	Liberty	Montgomery	Waller	
Brazoria	0	1173	18,785	72,465	3,527,086	2119	3743	1085	3,626,456
Chambers	6777	0	808	6016	439,615	843	831	120	455,010
Fort Bend	2958	22	0	641	144,920	49	173	66	148,829
Galveston	142,895	1168	6687	0	3,679,485	2324	5269	760	3,838,588
Harris	2,919,419	60,433	751,269	1,295,361	535,687	27,608	656,660	89,120	6,335,557
Liberty	103	25	54	250	17,234	0	118	9	17,793
Montgomery	1129	22	165	482	146,181	101	0	80	148,160
Waller	167	3	64	71	21,296	7	81	0	21,689
Totals	3,073,448	62,846	777,832	1,375,286	8,511,504	33,051	666,875	91,240	14,592,082

Table 5.3. Food Movements for HGA (Annual Tons).

Origin County	Destination County								Totals
	Brazoria	Chambers	Fort Bend	Galveston	Harris	Liberty	Montgomery	Waller	
Brazoria	0	606	11,059	11,387	192,118	1227	6934	731	224,062
Chambers	520	0	588	812	16,003	161	538	57	18,679
Fort Bend	10,766	667	0	9520	264,845	1471	8320	1275	296,864
Galveston	11,114	925	103	0	217,580	1664	7828	824	240,038
Harris	223,648	21,727	316,696	259,508	0	44,159	281,855	30,721	1,178,314
Liberty	823	126	1012	1144	25,449	0	1250	97	29,901
Montgomery	6923	626	8533	8008	241,751	1861	0	1286	268,988
Waller	566	51	1015	654	20,448	112	998	0	23,844
Totals	254,360	24,728	339,006	291,033	978,194	50,655	307,723	34,991	2,280,690

Table 5.4. Textile Movements for HGA (Annual Tons).

Origin County	Destination County								Totals
	Brazoria	Chambers	Fort Bend	Galveston	Harris	Liberty	Montgomery	Waller	
Brazoria	0	2	49	60	20,253	3	22	2	20,391
Chambers	3	0	2	2	980	0	1	0	988
Fort Bend	68	2	0	33	18,918	2	18	2	19,043
Galveston	93	3	37	0	20,556	3	23	2	20,717
Harris	8849	350	5895	5755	0	389	3811	333	25,382
Liberty	10	1	6	7	3494	0	5	0	3523
Montgomery	49	2	28	31	18,982	2	0	2	19,096
Waller	5	0	4	3	1986	0	3	0	2001
Totals	9077	360	6021	5891	85,169	399	3883	341	111,141

Table 5.5. Wood Movements for HGA (Annual Tons).

Origin County	Destination County								Totals
	Brazoria	Chambers	Fort Bend	Galveston	Harris	Liberty	Montgomery	Waller	
Brazoria	0	143	1992	1876	82,309	255	1138	166	87,879
Chambers	296	0	138	178	9221	47	118	18	10,016
Fort Bend	4106	137	0	1338	100,757	269	1197	262	108,066
Galveston	4546	208	1573	0	87,129	329	1199	176	95,160
Harris	176,880	9580	105,053	77,283	0	17,214	87,393	13,239	486,642
Liberty	795	69	406	422	24,929	0	480	51	27,152
Montgomery	2590	130	1322	1128	92,640	350	0	269	98,429
Waller	431	22	331	188	16,032	42	307	0	17,353
Totals	189,644	10,289	110,815	82,413	413,017	18,506	91,832	14,181	930,697

Table 5.6. Building Material Movements for HGA (Annual Tons).

Origin County	Destination County								Totals
	Brazoria	Chambers	Fort Bend	Galveston	Harris	Liberty	Montgomery	Waller	
Brazoria	0	722	5559	5782	401,963	976	3483	675	419,160
Chambers	359	0	227	324	26,641	105	214	42	27,912
Fort Bend	6872	566	0	3362	401,123	837	2989	869	416,618
Galveston	8911	1005	4191	0	406,150	1198	3507	680	425,642
Harris	521,963	69,607	421,291	342,165	0	94,517	384,865	77,407	1,911,815
Liberty	3294	714	2284	2622	245,668	0	2966	412	257,960
Montgomery	4576	565	3176	2989	389,319	1155	0	939	402,719
Waller	2632	326	2738	1719	232,396	476	2788	0	243,075
Totals	548,607	73,505	439,466	358,963	2,103,260	99,264	400,812	81,024	4,104,901

Table 5.7. Machinery Movements for HGA (Annual Tons).

Origin County	Destination County								Totals
	Brazoria	Chambers	Fort Bend	Galveston	Harris	Liberty	Montgomery	Waller	
Brazoria	0	1	2	17	37,351	1	2	1	37,375
Chambers	1	0	1	1	2451	0	1	0	2455
Fort Bend	17	1	0	6	36,108	1	2	1	36,136
Galveston	23	1	1	0	28,779	1	1	0	28,806
Harris	24,118	2036	4304	9707	0	367	7708	1719	49,959
Liberty	2	1	0	1	6674	0	1	0	6679
Montgomery	6	1	1	4	28,340	1	0	1	28,354
Waller	1	0	0	1	3635	0	1	0	3638
Totals	24,168	2041	4309	9737	143,338	371	7716	1722	193,402

Table 5.8. Secondary Movements for HGA (Annual Tons).

Origin County	Destination County								Totals
	Brazoria	Chambers	Fort Bend	Galveston	Harris	Liberty	Montgomery	Waller	
Brazoria	0	20	302	474	490,485	20	120	11	491,432
Chambers	11	0	9	29	45,500	6	9	1	45,565
Fort Bend	154	8	0	93	365,552	10	59	15	365,891
Galveston	414	44	158	0	515,117	32	124	12	515,901
Harris	711,992	115,816	1,035,205	855,360	0	112,930	992,851	100,351	3,924,505
Liberty	17	8	16	32	66,705	0	35	1	66,814
Montgomery	68	9	67	81	390,442	24	0	20	390,711
Waller	8	1	19	9	46,295	1	24	0	46,357
Totals	712,664	115,904	1,035,776	856,078	1,920,096	113,023	993,222	100,411	5,847,176

“BOTTOM-UP” MODEL APPLICATION

The Houston-Galveston urban travel demand model is unique with respect to other urban area models because the model uses six categories of employment, industrial, retail, education, office, medical, and government. The workplace survey conducted in the HGA in 1995 provided estimates of truck/taxi attractions per employee for the six employment categories stratified by five area types (75). Table 5.9 presents the recommended rates developed from that survey. It should be noted that the rates shown in Table 5.9 do not differentiate between cargo transport vehicles and service vehicles and include rates for taxis (taxi rates are not considered to be a significant portion of the overall rate).

Table 5.9. Houston-Galveston Truck/Taxi Attractions Per Employee.

Land Use Type	Area Type				
	1	2	3	4	5
Industrial	0.233	0.429	0.678	0.678	0.015
Retail	0.155	0.249	0.093	0.093	0.499
Medical	0.035	0.031	0.014	0.014	0.009
Office	0.017	0.109	0.035	0.035	0.022
Education	0.119	0.125	0.298	0.298	0.136
Government	0.005	0.005	0.005	0.005	0.005

A truck attraction rate for households in the HGA was estimated using data from the commercial vehicle survey (76) and the workplace survey. The percentage of commercial vehicles attracted to residential land uses was 22 percent. The total estimate of truck/taxi attractions based on the workplace survey was 276,323 (75). The estimated number of truck/taxi attractions to residential land uses was 77,937 which divided by the estimated number of households in the HGA of 1,338,773 (77) (in 1995 at the time of the surveys) produced an attraction rate of 0.058 trips per household. It is assumed that this rate is the same for all area types.

The rates shown in Table 5.9 and the rate for households include commercial service vehicles as well as commercial cargo transport vehicles. Commercial service vehicles are those that are used for commercial purposes but not for the purpose of transporting cargo. To obtain reasonable estimates of commodity movements, these rates must be adjusted to exclude commercial service vehicles. In the 1995 Houston-Galveston travel surveys, special surveys of commercial passenger transport vehicles were done. These vehicles included ambulances, taxis, school buses, private non-profit passenger carriers, public passenger carriers (excluding public transportation), and charter buses. The estimated number of daily trips attributed to these commercial passenger carrier vehicles was 32,676 (78). This number represented approximately 12 percent of the total truck/taxi attractions estimated from the work place survey.

It is believed that the number of commercial service vehicles in operation exceeds the number of cargo transport vehicles in operation. For example, in the Houston-Galveston commercial vehicle survey, single unit two-axle vehicles comprised over 57 percent of the vehicles surveyed. Since the survey was random, it may be expected that this percent is a reasonable approximation

of the percentage in the total population at the time of the survey. For purposes of this research, it was assumed that 50 percent of the vehicle population and vehicle trips are commercial service vehicles. Combining this percentage with that for the commercial passenger carrier vehicles indicates the attraction rates in Table 5.9 and that for households should be reduced by 62 percent. Table 5.10 shows the resulting attraction rates for commercial cargo transport vehicles.

Table 5.10. Houston-Galveston Commercial Cargo Transport Attractions Per Employee.

Land Use Type	Area Type				
	1	2	3	4	5
Industrial	0.089	0.163	0.258	0.258	0.006
Retail	0.059	0.095	0.035	0.035	0.190
Medical	0.013	0.012	0.005	0.005	0.003
Office	0.006	0.041	0.013	0.013	0.008
Education	0.045	0.048	0.113	0.113	0.052
Government	0.002	0.002	0.002	0.002	0.002
Residential	0.022	0.022	0.022	0.022	0.022

Table 5.11 presents the estimates of employment and households by area type based on the zonal demographic data provided by the Houston-Galveston Area Council of Governments. Since these data represent significant changes in the totals and distributions estimated in the 1995 surveys, it is believed the estimates in Table 5.11 are for the base year 1998.

Table 5.11. Houston-Galveston Socio-Demographic Data.

Land Use Type	Area Type				
	1	2	3	4	5
Industrial	12,662	105,666	199,238	76,991	21,686
Retail	11,876	123,559	242,981	75,709	13,888
Medical	3673	69,632	67,470	20,890	1665
Office	86,137	220,660	285,535	75,453	16,199
Education	1817	32,143	69,435	25,825	7758
Government	19,795	22,687	37,044	15,503	5322
Residential	441	242,830	799,395	324,789	118,213

Multiplying the demographic estimates in Table 5.11 by the attraction rates in Table 5.10 produces an estimate of 177,377 commercial cargo transport vehicle trips per day in the HGA. It is recognized that the rates in Table 5.10 have been significantly adjusted based on some broad assumptions. For purposes of this research, this conclusion is felt to be reasonable given that the surveys in 1995 in the HGA were not designed to capture estimates of commercial service and commercial cargo transport vehicles. These data are potential improvements that may be incorporated into future travel surveys to provide specific estimates for the proposed commodity flow modeling efforts.

The next step was to process the data from the Houston-Galveston commercial vehicle survey to produce the needed distributions and estimates of average cargo weights per vehicle trip. The data were first edited to remove those vehicles (and their recorded trips) that were identified as likely commercial service vehicles. The basis for this determination was whether the vehicle recorded any deliveries and/or pick ups of cargo. If none were recorded, the vehicle and its associated data were removed from the file. A specific computer program was written to accomplish this task. Essentially, the program produced the following data:

1. Grouped the recorded cargo codes into the equivalent groups used in the SAM.
2. Identified the vehicle trips shipping and receiving cargo by cargo type.
3. Estimated the weight of the cargo being shipped and received by land use.
4. Computed the percent distribution of trips by cargo being shipped and received as well as the percent of trips that were recorded as empty.
5. Computed the percent distribution of trips by cargo and land use where the cargo was actually transferred.
6. Computed the average trip length for each cargo type being transported.

Appendix C of this report contains the source code for this program (written in Fortran). It should be noted that this is not a generic program and was designed only to process the Houston-Galveston commercial survey data. The production of these data for other urban areas should be a specification in the analysis of commercial vehicle surveys.

The computation of the average weight per vehicle trip being shipped and received by commodity group and land use was done using the logic presented in Chapter 4. The initial computations used pounds per vehicle trip. After some examples were computed and the final rates calculated, it was determined that the use of pounds produced numbers that were too large for the TRIPCAL5 program and the use of tons produced rates too small to be input to TRIPCAL5. These computations were limitations in the software that could have been modified but the decision was made to develop rates based on quarter tons per vehicle trip. These rates could be input into TRIPCAL5 and the results fit within the formatting limits of the software. The final values could then be factored at a later stage in the modeling process. Tables 5.12 and 5.13 present the average quarter tons of cargo being shipped and received computed from the survey data by cargo group and land use.

Table 5.12. Average Shipping Weights¹ Per Vehicle Trip by Cargo Group and Land Use.

Commodity	Land Use						
	Residential	Industrial	Retail	Medical	Office	Education	Government
Agriculture	5.75	4.28	2.33	1.77	1.80	0.00	0.00
Raw Materials	15.67	34.88	28.52	81.19	16.25	35.10	0.00
Food	3.15	25.02	10.59	4.98	17.34	7.70	0.00
Textiles	1.08	2.73	2.34	0.00	2.16	0.00	0.00
Wood	10.28	9.05	9.03	0.00	3.94	0.00	0.00
Building Materials	18.03	30.10	17.86	17.18	5.98	54.66	19.41
Machinery	4.25	4.27	4.37	3.49	4.18	0.00	3.43
Miscellaneous	10.91	12.41	10.10	0.00	11.16	6.53	2.77
Secondary	2.82	5.35	6.51	0.00	6.93	0.00	0.00
Hazardous	7.76	9.84	16.38	0.00	0.00	0.00	3.90

¹All weights are in quarter tons (i.e., 500 pounds).

Table 5.13. Average Receiving Weights¹ Per Vehicle Trip by Cargo Group and Land Use.

Commodity	Land Use						
	Residential	Industrial	Retail	Medical	Office	Education	Government
Agriculture	1.29	6.16	1.25	1.66	1.76	0.00	0.00
Raw Materials	0.72	16.35	48.52	0.00	5.20	36.64	1.59
Food	3.18	23.05	1.46	1.74	7.68	2.79	1.47
Textiles	1.51	1.08	1.04	0.50	0.43	1.25	0.00
Wood	9.16	7.96	10.66	2.04	1.37	6.79	0.00
Building Materials	22.11	30.26	14.53	4.54	14.44	11.59	17.76
Machinery	3.08	3.60	3.65	1.06	3.95	2.46	3.59
Miscellaneous	7.13	12.61	6.85	10.41	4.15	6.02	0.94
Secondary	6.61	3.09	2.18	0.00	5.86	0.00	0.00
Hazardous	1.50	6.79	9.56	0.00	0.00	0.68	0.00

¹All weights are in quarter tons (i.e., 500 pounds).

The cargo codes recorded in the survey were grouped based on the equivalencies shown in Table 4.5. Table 5.14 shows the number of surveyed trips identified by land use, commodity group, and the type of movement, i.e. shipping or receiving. It will be noted that one of the commodity groups shown in Table 5.12 is unknown. These trips were proportionally distributed to the ten commodity groups within each land use category by type of movement. Table 5.15 presents the percent distributions used in the rate computations.

Table 5.14. Survey Trips by Commodity Group and Land Use.

Commodity	Land Use							
	Action	Residential	Industrial	Retail	Medical	Office	Education	Government
Agriculture	Shipping	8	10	12	2	9	0	0
	Receiving	13	6	12	1	9	0	0
Raw Materials	Shipping	367	250	47	1	16	7	0
	Receiving	368	250	51	1	13	8	1
Food	Shipping	1	64	308	3	2	19	2
	Receiving	1	65	308	3	4	19	2
Textiles	Shipping	12	97	51	6	8	2	0
	Receiving	12	95	51	6	9	2	0
Wood	Shipping	24	38	9	3	21	2	1
	Receiving	25	32	9	3	22	4	1
Building Materials	Shipping	31	378	20	12	17	17	7
	Receiving	99	292	36	8	18	20	10
Machinery	Shipping	32	154	43	20	48	6	5
	Receiving	32	159	40	23	48	6	3
Miscellaneous	Shipping	54	90	18	2	19	5	4
	Receiving	51	97	15	2	19	2	3
Secondary	Shipping	19	25	6	0	5	0	0
	Receiving	22	20	5	0	4	0	0
Hazardous	Shipping	32	36	5	0	1	1	1
	Receiving	31	35	6	0	1	1	1
Unknown	Shipping	7	4	2	0	6	0	0
	Receiving	4	5	2	0	7	0	0
Empty	Shipping	102	282	50	3	21	10	3
	Receiving	24	371	30	7	33	10	2

Table 5.15. Percent Distribution of Trips by Cargo Group and Land Use.

Commodity	Land Use							
	Action	Residential	Industrial	Retail	Medical	Office	Education	Government
Agriculture	Shipping	1.23	0.73	2.20	3.97	5.45	0.00	0.00
	Receiving	2.01	0.44	2.24	1.91	5.08	0.00	0.00
Raw Materials	Shipping	51.45	16.68	7.86	1.81	8.83	9.67	0.00
	Receiving	51.42	16.63	8.62	1.73	6.64	10.66	4.08
Food	Shipping	0.15	4.45	53.68	5.65	1.15	27.37	8.43
	Receiving	0.15	4.50	54.17	5.41	2.13	26.35	8.49
Textiles	Shipping	1.71	6.58	8.68	11.04	4.49	2.81	0.00
	Receiving	1.73	6.51	8.87	10.70	4.73	2.74	0.00
Wood	Shipping	3.43	2.58	1.53	5.52	11.81	2.82	4.12
	Receiving	3.65	2.23	1.59	5.43	11.75	5.57	4.27
Building Materials	Shipping	4.46	25.91	3.44	22.28	9.64	24.14	29.07
	Receiving	14.27	20.03	6.27	14.29	9.48	27.49	42.04
Machinery	Shipping	4.93	11.29	7.90	39.75	29.14	9.12	22.22
	Receiving	4.91	11.62	7.42	43.76	26.92	8.78	13.44
Miscellaneous	Shipping	9.11	7.22	3.62	4.35	12.62	8.31	19.45
	Receiving	8.76	7.93	3.12	4.26	11.93	3.28	15.03
Secondary	Shipping	4.12	2.58	1.55	0.00	4.27	0.00	0.00
	Receiving	5.16	2.23	1.42	0.00	3.43	0.00	0.00
Hazardous	Shipping	4.56	2.44	0.85	0.00	0.56	1.41	4.11
	Receiving	4.49	2.41	1.05	0.00	0.53	1.38	4.23
Empty	Shipping	14.85	19.54	8.69	5.63	12.04	14.36	12.60
	Receiving	3.46	25.47	5.23	12.51	17.39	13.75	8.42

The percentage of vehicles that actually transferred cargo as also computed by cargo group, land use, and shipping/receiving. Table 5.16 shows these results.

Table 5.16. Percent Distribution of Vehicle Trips Transferring Cargo.

Commodity	Land Use							
	Action	Residential	Industrial	Retail	Medical	Office	Education	Government
Agriculture	Shipping	14.88	74.16	19.80	55.35	36.54	0.00	0.00
	Receiving	78.86	58.54	77.73	100.00	56.89	0.00	0.00
Raw Materials	Shipping	2.76	48.61	8.73	100.00	55.22	29.23	0.00
	Receiving	94.06	49.83	89.60	0.00	20.98	87.02	100.00
Food	Shipping	100.00	68.81	7.68	35.19	50.21	22.45	0.00
	Receiving	100.00	63.60	93.08	64.39	71.49	88.49	100.00
Textiles	Shipping	32.95	32.73	27.28	0.00	48.06	0.00	0.00
	Receiving	63.88	73.14	68.60	100.00	19.73	100.00	0.00
Wood	Shipping	25.83	59.09	78.68	0.00	18.80	0.00	0.00
	Receiving	100.00	43.59	9.77	100.00	68.59	46.97	0.00
Building Materials	Shipping	12.76	72.07	29.91	66.68	39.42	5.89	14.29
	Receiving	95.39	68.46	93.84	47.82	40.39	100.00	78.57
Machinery	Shipping	30.26	48.32	36.33	9.70	59.96	0.00	39.20
	Receiving	63.34	51.97	50.74	81.90	42.70	65.58	65.58
Miscellaneous	Shipping	28.89	51.51	51.60	0.00	52.50	41.65	51.71
	Receiving	71.40	53.26	28.34	100.00	21.07	44.71	28.79
Secondary	Shipping	15.77	63.41	44.52	0.00	49.96	0.00	0.00
	Receiving	71.91	21.91	62.47	0.00	54.13	0.00	0.00
Hazardous	Shipping	15.56	38.89	40.08	0.00	0.00	0.00	100.00
	Receiving	56.37	59.29	65.76	0.00	42.70	100.00	0.00

Using the data from Tables 5.10, 5.12, 5.13, 5.15, and 5.16, shipping and receiving rates by cargo group and land use category were computed. These rates provide a means by which the quarter tons of each commodity group being shipped and received by zone may be estimated. Rates are also developed for those vehicle movements where cargo is transported but no transfer is made and for those vehicle movements where the vehicle is empty. These rates are shown in Tables 5.17, 5.18, 5.19, 5.20, and 5.21.

To utilize the rates developed, the setup for TRIPCAL5 must be structured as a cross-classification regression model for both trip productions and attractions. This nomenclature is used in this report because it relates to the typical setups used in the trip generation step for travel demand modeling. It should be realized, however, that the modeling of commodity flows requires a generation run to estimate the amount of each commodity being shipped and received for each zone. If the intent is to model truck movements, two additional runs will be required, one to estimate the non-transfer vehicle movements and one to estimate the empty vehicle movements.

To set up TRIPCAL5 to estimate commodity shipping and receiving for each zone, each commodity is essentially treated as a trip purpose. The regional distribution for the urban area must be computed to reflect the percentage of households, basic, retail, and service employment by area type. This distribution may be computed using the EA and DA1 records for an urban area. In addition, DA2, DA3, and DA4 records are required for the TRIPCAL5 setup. To assist in the development of these data, a GISDK program was written to produce the PCR records,

DA2, DA3, and DA4 records using the EA and DA1 records for an urban area. These data are those used in a typical travel demand model for an urban area and do not impose an additional requirement for the modeler. Appendix D of this reports contains the GISDK program and operating instructions. The reader is referred to reference 74 for descriptions and details on the DA2, DA3, and DA4 records in the TRIPCAL5 setup. The program setup also requires the use of the cross classification variable (CCV) record identifying the production and attraction cross classification variable as 10.

The TRIPCAL5 program setup for the HGA is unique because of the number of employment categories used in their travel demand models. The number exceeds the capability of TRIPCAL5 and in order to use the program for the Houston-Galveston area, it was necessary to have two setups, one for estimating based on households, industrial employment, and retail employment and one for estimating based on medical, office, education, and government employment. The results were then combined after each run to produce generation records for input to the second step, trip distribution.

To demonstrate the model, TRIPCAL5 was used using the rates developed and shown in Tables 5.17, 5.18, 5.19, 5.20, and 5.21. TRIPCAL5 required six program setups with the results being combined to produce the following files:

- generation records with zonal estimates of commodities shipped and received,
- generation records with zonal estimates of vehicle trips where cargo was not transferred, and
- generation records with zonal estimates of empty vehicle trips.

Table 5.17. Commodity Shipping Rates.

Residential – Quarter Tons Per Household					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0002	0.0002	0.0002	0.0002	0.0002
Raw Materials	0.0049	0.0049	0.0049	0.0049	0.0049
Food	0.0001	0.0001	0.0001	0.0001	0.0001
Textiles	0.0001	0.0001	0.0001	0.0001	0.0001
Wood	0.0020	0.0020	0.0020	0.0020	0.0020
Building Materials	0.0023	0.0023	0.0023	0.0023	0.0023
Machinery	0.0014	0.0014	0.0014	0.0014	0.0014
Miscellaneous	0.0063	0.0063	0.0063	0.0063	0.0063
Secondary	0.0004	0.0004	0.0004	0.0004	0.0004
Hazardous	0.0012	0.0012	0.0012	0.0012	0.0012
Industrial Land Use – Quarter Tons Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0021	0.0038	0.0060	0.0060	0.0001
Raw Materials	0.2517	0.4611	0.7298	0.7298	0.0170
Food	0.0682	0.1250	0.1978	0.1978	0.0046
Textiles	0.0052	0.0096	0.0152	0.0152	0.0004
Wood	0.0123	0.0225	0.0356	0.0356	0.0008
Building Materials	0.5005	0.9166	1.4508	1.4508	0.0337
Machinery	0.0207	0.0380	0.0601	0.0601	0.0014
Miscellaneous	0.0411	0.0753	0.1192	0.1192	0.0028
Secondary	0.0078	0.0143	0.0226	0.0226	0.0005
Hazardous	0.0083	0.0153	0.0241	0.0241	0.0006
Retail Land Use – Quarter Tons Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0006	0.0010	0.0004	0.0004	0.0019
Raw Materials	0.0115	0.0186	0.0068	0.0068	0.0372
Food	0.0257	0.0414	0.0153	0.0153	0.0829
Textiles	0.0033	0.0053	0.0019	0.0019	0.0105
Wood	0.0064	0.0104	0.0038	0.0038	0.0207
Building Materials	0.0108	0.0174	0.0064	0.0064	0.0349
Machinery	0.0074	0.0119	0.0044	0.0044	0.0239
Miscellaneous	0.0111	0.0179	0.0066	0.0066	0.0359
Secondary	0.0027	0.0043	0.0016	0.0016	0.0086
Hazardous	0.0033	0.0053	0.0020	0.0020	0.0106
Medical Land Use – Quarter Tons Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0005	0.0005	0.0002	0.0002	0.0001
Raw Materials	0.0191	0.0176	0.0073	0.0073	0.0044
Food	0.0013	0.0012	0.0005	0.0005	0.0003
Textiles	0.0000	0.0000	0.0000	0.0000	0.0000
Wood	0.0000	0.0000	0.0000	0.0000	0.0000
Building Materials	0.0332	0.0306	0.0128	0.0128	0.0077
Machinery	0.0018	0.0016	0.0007	0.0007	0.0004
Miscellaneous	0.0000	0.0000	0.0000	0.0000	0.0000
Secondary	0.0000	0.0000	0.0000	0.0000	0.0000
Hazardous	0.0000	0.0000	0.0000	0.0000	0.0000

Table 5.17. Commodity Shipping Rates (Cont.).

Office Land Use – Quarter Tons Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0002	0.0015	0.0005	0.0005	0.0003
Raw Materials	0.0047	0.0324	0.0103	0.0103	0.0063
Food	0.0006	0.0041	0.0013	0.0013	0.0008
Textiles	0.0003	0.0019	0.0006	0.0006	0.0004
Wood	0.0005	0.0036	0.0011	0.0011	0.0007
Building Materials	0.0014	0.0093	0.0029	0.0029	0.0018
Machinery	0.0044	0.0298	0.0095	0.0095	0.0058
Miscellaneous	0.0047	0.0318	0.0101	0.0101	0.0062
Secondary	0.0009	0.0061	0.0019	0.0019	0.0012
Hazardous	0.0000	0.0000	0.0000	0.0000	0.0000
Education Land Use – Quarter Tons Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0000	0.0000	0.0000	0.0000	0.0000
Raw Materials	0.0447	0.0476	0.1122	0.1122	0.0516
Food	0.0213	0.0227	0.0535	0.0535	0.0246
Textiles	0.0000	0.0000	0.0000	0.0000	0.0000
Wood	0.0000	0.0000	0.0000	0.0000	0.0000
Building Materials	0.0349	0.0373	0.0877	0.0877	0.0404
Machinery	0.0000	0.0000	0.0000	0.0000	0.0000
Miscellaneous	0.0102	0.0108	0.0255	0.0255	0.0118
Secondary	0.0000	0.0000	0.0000	0.0000	0.0000
Hazardous	0.0000	0.0000	0.0000	0.0000	0.0000
Government Land Use – Quarter Tons Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0000	0.0000	0.0000	0.0000	0.0000
Raw Materials	0.0000	0.0000	0.0000	0.0000	0.0000
Food	0.0000	0.0000	0.0000	0.0000	0.0000
Textiles	0.0000	0.0000	0.0000	0.0000	0.0000
Wood	0.0000	0.0000	0.0000	0.0000	0.0000
Building Materials	0.0016	0.0016	0.0016	0.0016	0.0016
Machinery	0.0006	0.0006	0.0006	0.0006	0.0006
Miscellaneous	0.0006	0.0006	0.0006	0.0006	0.0006
Secondary	0.0000	0.0000	0.0000	0.0000	0.0000
Hazardous	0.0003	0.0003	0.0003	0.0003	0.0003

Table 5.18. Commodity Receiving Rates.

Residential – Quarter Tons Per Household					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0004	0.0004	0.0004	0.0004	0.0004
Raw Materials	0.0077	0.0077	0.0077	0.0077	0.0077
Food	0.0001	0.0001	0.0001	0.0001	0.0001
Textiles	0.0004	0.0004	0.0004	0.0004	0.0004
Wood	0.0073	0.0073	0.0073	0.0073	0.0073
Building Materials	0.0659	0.0659	0.0659	0.0659	0.0659
Machinery	0.0021	0.0021	0.0021	0.0021	0.0021
Miscellaneous	0.0103	0.0103	0.0103	0.0103	0.0103
Secondary	0.0054	0.0054	0.0054	0.0054	0.0054
Hazardous	0.0008	0.0008	0.0008	0.0008	0.0008
Industrial Land Use – Quarter Tons Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0014	0.0026	0.0041	0.0041	0.0001
Raw Materials	0.1208	0.2212	0.3501	0.3501	0.0081
Food	0.0588	0.1077	0.1704	0.1704	0.0040
Textiles	0.0046	0.0084	0.0133	0.0133	0.0003
Wood	0.0069	0.0126	0.0200	0.0200	0.0005
Building Materials	0.3698	0.6773	1.0720	1.0720	0.0249
Machinery	0.0193	0.0354	0.0561	0.0561	0.0013
Miscellaneous	0.0475	0.0870	0.1376	0.1376	0.0032
Secondary	0.0013	0.0025	0.0039	0.0039	0.0001
Hazardous	0.0087	0.0159	0.0251	0.0251	0.0006
Retail Land Use – Quarter Tons Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0013	0.0021	0.0008	0.0008	0.0041
Raw Materials	0.2211	0.3560	0.1312	0.1312	0.7121
Food	0.0433	0.0697	0.0257	0.0257	0.1395
Textiles	0.0037	0.0060	0.0022	0.0022	0.0120
Wood	0.0010	0.0016	0.0006	0.0006	0.0031
Building Materials	0.0505	0.0813	0.0299	0.0299	0.1625
Machinery	0.0081	0.0131	0.0048	0.0048	0.0261
Miscellaneous	0.0036	0.0058	0.0021	0.0021	0.0115
Secondary	0.0011	0.0018	0.0007	0.0007	0.0037
Hazardous	0.0039	0.0063	0.0023	0.0023	0.0126
Medical Land Use – Quarter Tons Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0004	0.0004	0.0002	0.0002	0.0001
Raw Materials	0.0000	0.0000	0.0000	0.0000	0.0000
Food	0.0008	0.0007	0.0003	0.0003	0.0002
Textiles	0.0007	0.0006	0.0003	0.0003	0.0002
Wood	0.0014	0.0013	0.0006	0.0006	0.0003
Building Materials	0.0040	0.0037	0.0015	0.0015	0.0009
Machinery	0.0049	0.0046	0.0019	0.0019	0.0011
Miscellaneous	0.0058	0.0053	0.0022	0.0022	0.0013
Secondary	0.0000	0.0000	0.0000	0.0000	0.0000
Hazardous	0.0000	0.0000	0.0000	0.0000	0.0000

Table 5.18. Commodity Receiving Rates (Cont.).

Office Land Use – Quarter Tons Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0003	0.0021	0.0007	0.0007	0.0004
Raw Materials	0.0004	0.0030	0.0009	0.0009	0.0006
Food	0.0007	0.0048	0.0015	0.0015	0.0009
Textiles	0.0000	0.0002	0.0001	0.0001	0.0001
Wood	0.0007	0.0045	0.0014	0.0014	0.0009
Building Materials	0.0033	0.0227	0.0072	0.0072	0.0044
Machinery	0.0027	0.0186	0.0059	0.0059	0.0036
Miscellaneous	0.0007	0.0045	0.0014	0.0014	0.0009
Secondary	0.0007	0.0045	0.0014	0.0014	0.0009
Hazardous	0.0000	0.0000	0.0000	0.0000	0.0000
Education Land Use – Quarter Tons Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0000	0.0000	0.0000	0.0000	0.0000
Raw Materials	0.1530	0.1632	0.3841	0.3841	0.1767
Food	0.0293	0.0312	0.0735	0.0735	0.0338
Textiles	0.0015	0.0016	0.0039	0.0039	0.0018
Wood	0.0080	0.0085	0.0201	0.0201	0.0093
Building Materials	0.1433	0.1529	0.3600	0.3600	0.1656
Machinery	0.0064	0.0068	0.0160	0.0160	0.0074
Miscellaneous	0.0040	0.0042	0.0100	0.0100	0.0046
Secondary	0.0000	0.0000	0.0000	0.0000	0.0000
Hazardous	0.0004	0.0005	0.0011	0.0011	0.0005
Government Land Use – Quarter Tons Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0000	0.0000	0.0000	0.0000	0.0000
Raw Materials	0.0001	0.0001	0.0001	0.0001	0.0001
Food	0.0002	0.0002	0.0002	0.0002	0.0002
Textiles	0.0000	0.0000	0.0000	0.0000	0.0000
Wood	0.0000	0.0000	0.0000	0.0000	0.0000
Building Materials	0.0117	0.0117	0.0117	0.0117	0.0117
Machinery	0.0006	0.0006	0.0006	0.0006	0.0006
Miscellaneous	0.0001	0.0001	0.0001	0.0001	0.0001
Secondary	0.0000	0.0000	0.0000	0.0000	0.0000
Hazardous	0.0000	0.0000	0.0000	0.0000	0.0000

Table 5.19. Vehicle Trip Production Rates for Non-Transfer Movements.

Residential –Vehicle Trips Per Household					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0002	0.0002	0.0002	0.0002	0.0002
Raw Materials	0.0110	0.0110	0.0110	0.0110	0.0110
Food	0.0000	0.0000	0.0000	0.0000	0.0000
Textiles	0.0003	0.0003	0.0003	0.0003	0.0003
Wood	0.0006	0.0006	0.0006	0.0006	0.0006
Building Materials	0.0009	0.0009	0.0009	0.0009	0.0009
Machinery	0.0008	0.0008	0.0008	0.0008	0.0008
Miscellaneous	0.0014	0.0014	0.0014	0.0014	0.0014
Secondary	0.0008	0.0008	0.0008	0.0008	0.0008
Hazardous	0.0008	0.0008	0.0008	0.0008	0.0008
Industrial Land Use –Vehicle Trips Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0002	0.0003	0.0005	0.0005	0.0000
Raw Materials	0.0076	0.0140	0.0221	0.0221	0.0005
Food	0.0012	0.0023	0.0036	0.0036	0.0001
Textiles	0.0039	0.0072	0.0114	0.0114	0.0003
Wood	0.0009	0.0017	0.0027	0.0027	0.0001
Building Materials	0.0064	0.0118	0.0187	0.0187	0.0004
Machinery	0.0052	0.0095	0.0151	0.0151	0.0004
Miscellaneous	0.0031	0.0057	0.0090	0.0090	0.0002
Secondary	0.0008	0.0015	0.0024	0.0024	0.0001
Hazardous	0.0013	0.0024	0.0039	0.0039	0.0001
Retail Land Use – Vehicle Trips Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0010	0.0017	0.0006	0.0006	0.0034
Raw Materials	0.0042	0.0068	0.0025	0.0025	0.0136
Food	0.0293	0.0471	0.0174	0.0174	0.0942
Textiles	0.0037	0.0060	0.0022	0.0022	0.0120
Wood	0.0002	0.0003	0.0001	0.0001	0.0006
Building Materials	0.0014	0.0023	0.0008	0.0008	0.0046
Machinery	0.0030	0.0048	0.0018	0.0018	0.0096
Miscellaneous	0.0010	0.0017	0.0006	0.0006	0.0033
Secondary	0.0005	0.0008	0.0003	0.0003	0.0016
Hazardous	0.0003	0.0005	0.0002	0.0002	0.0010
Medical Land Use – Vehicle Trips Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0002	0.0002	0.0001	0.0001	0.0001
Raw Materials	0.0000	0.0000	0.0000	0.0000	0.0000
Food	0.0005	0.0004	0.0002	0.0002	0.0001
Textiles	0.0014	0.0013	0.0006	0.0006	0.0003
Wood	0.0007	0.0007	0.0003	0.0003	0.0002
Building Materials	0.0010	0.0009	0.0004	0.0004	0.0002
Machinery	0.0047	0.0043	0.0018	0.0018	0.0011
Miscellaneous	0.0006	0.0005	0.0002	0.0002	0.0001
Secondary	0.0000	0.0000	0.0000	0.0000	0.0000
Hazardous	0.0000	0.0000	0.0000	0.0000	0.0000

Table 5.19. Vehicle Trip Production Rates for Non-Transfer Movements (Cont.).

Office Land Use – Vehicle Trips Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0002	0.0014	0.0004	0.0004	0.0003
Raw Materials	0.0002	0.0016	0.0005	0.0005	0.0003
Food	0.0001	0.0002	0.0001	0.0001	0.0001
Textiles	0.0001	0.0010	0.0003	0.0003	0.0002
Wood	0.0006	0.0039	0.0012	0.0012	0.0008
Building Materials	0.0004	0.0024	0.0008	0.0008	0.0005
Machinery	0.0007	0.0048	0.0015	0.0015	0.0009
Miscellaneous	0.0004	0.0026	0.0008	0.0008	0.0005
Secondary	0.0001	0.0009	0.0003	0.0003	0.0002
Hazardous	0.0001	0.0002	0.0001	0.0001	0.0001
Education Land Use – Vehicle Trips Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0000	0.0000	0.0000	0.0000	0.0000
Raw Materials	0.0031	0.0033	0.0077	0.0077	0.0036
Food	0.0096	0.0102	0.0240	0.0240	0.0110
Textiles	0.0013	0.0014	0.0032	0.0032	0.0015
Wood	0.0013	0.0014	0.0032	0.0032	0.0015
Building Materials	0.0102	0.0109	0.0257	0.0257	0.0118
Machinery	0.0041	0.0044	0.0103	0.0103	0.0047
Miscellaneous	0.0022	0.0023	0.0055	0.0055	0.0025
Secondary	0.0000	0.0000	0.0000	0.0000	0.0000
Hazardous	0.0006	0.0007	0.0016	0.0016	0.0007
Government Land Use - Vehicle Trips Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0000	0.0000	0.0000	0.0000	0.0000
Raw Materials	0.0000	0.0000	0.0000	0.0000	0.0000
Food	0.0002	0.0002	0.0002	0.0002	0.0002
Textiles	0.0000	0.0000	0.0000	0.0000	0.0000
Wood	0.0001	0.0001	0.0001	0.0001	0.0001
Building Materials	0.0005	0.0005	0.0005	0.0005	0.0005
Machinery	0.0003	0.0003	0.0003	0.0003	0.0003
Miscellaneous	0.0002	0.0002	0.0002	0.0002	0.0002
Secondary	0.0000	0.0000	0.0000	0.0000	0.0000
Hazardous	0.0000	0.0000	0.0000	0.0000	0.0000

Table 5.20. Vehicle Trip Attraction Rates for Non-Transfer Movements.

Residential – Vehicle Trips Per Household					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0001	0.0001	0.0001	0.0001	0.0001
Raw Materials	0.0007	0.0007	0.0007	0.0007	0.0007
Food	0.0000	0.0000	0.0000	0.0000	0.0000
Textiles	0.0001	0.0001	0.0001	0.0001	0.0001
Wood	0.0000	0.0000	0.0000	0.0000	0.0000
Building Materials	0.0001	0.0001	0.0001	0.0001	0.0001
Machinery	0.0004	0.0004	0.0004	0.0004	0.0004
Miscellaneous	0.0006	0.0006	0.0006	0.0006	0.0006
Secondary	0.0003	0.0003	0.0003	0.0003	0.0003
Hazardous	0.0004	0.0004	0.0004	0.0004	0.0004
Industrial Land Use – Vehicle Trips Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0002	0.0003	0.0005	0.0005	0.0001
Raw Materials	0.0074	0.0136	0.0216	0.0216	0.0005
Food	0.0015	0.0027	0.0042	0.0042	0.0001
Textiles	0.0016	0.0029	0.0045	0.0045	0.0001
Wood	0.0011	0.0021	0.0032	0.0032	0.0001
Building Materials	0.0056	0.0103	0.0163	0.0163	0.0004
Machinery	0.0050	0.0091	0.0144	0.0144	0.0003
Miscellaneous	0.0033	0.0061	0.0096	0.0096	0.0002
Secondary	0.0016	0.0028	0.0045	0.0045	0.0001
Hazardous	0.0009	0.0016	0.0025	0.0025	0.0001
Retail Land Use – Vehicle Trips Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0003	0.0005	0.0002	0.0002	0.0009
Raw Materials	0.0005	0.0009	0.0003	0.0003	0.0017
Food	0.0022	0.0036	0.0013	0.0013	0.0071
Textiles	0.0016	0.0026	0.0010	0.0010	0.0053
Wood	0.0008	0.0014	0.0005	0.0005	0.0027
Building Materials	0.0002	0.0004	0.0001	0.0001	0.0007
Machinery	0.0022	0.0035	0.0013	0.0013	0.0070
Miscellaneous	0.0013	0.0021	0.0008	0.0008	0.0042
Secondary	0.0003	0.0005	0.0002	0.0002	0.0010
Hazardous	0.0002	0.0003	0.0001	0.0001	0.0007
Medical Land Use – Vehicle Trips Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0000	0.0000	0.0000	0.0000	0.0000
Raw Materials	0.0002	0.0002	0.0001	0.0001	0.0001
Food	0.0003	0.0002	0.0001	0.0001	0.0001
Textiles	0.0000	0.0000	0.0000	0.0000	0.0000
Wood	0.0000	0.0000	0.0000	0.0000	0.0000
Building Materials	0.0010	0.0009	0.0004	0.0004	0.0002
Machinery	0.0010	0.0010	0.0004	0.0004	0.0002
Miscellaneous	0.0000	0.0000	0.0000	0.0000	0.0000
Secondary	0.0000	0.0000	0.0000	0.0000	0.0000
Hazardous	0.0000	0.0000	0.0000	0.0000	0.0000

Table 5.20. Vehicle Trip Attraction Rates for Non-Transfer Movements (Cont.).

Office Land Use – Vehicle Trips Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0001	0.0009	0.0003	0.0003	0.0002
Raw Materials	0.0003	0.0022	0.0007	0.0007	0.0004
Food	0.0001	0.0003	0.0001	0.0001	0.0001
Textiles	0.0002	0.0016	0.0005	0.0005	0.0003
Wood	0.0002	0.0016	0.0005	0.0005	0.0003
Building Materials	0.0003	0.0023	0.0007	0.0007	0.0005
Machinery	0.0009	0.0063	0.0020	0.0020	0.0012
Miscellaneous	0.0006	0.0041	0.0013	0.0013	0.0008
Secondary	0.0001	0.0006	0.0002	0.0002	0.0001
Hazardous	0.0000	0.0001	0.0000	0.0000	0.0000
Education Land Use – Vehicle Trips Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0000	0.0000	0.0000	0.0000	0.0000
Raw Materials	0.0006	0.0007	0.0016	0.0016	0.0007
Food	0.0014	0.0015	0.0034	0.0034	0.0016
Textiles	0.0000	0.0000	0.0000	0.0000	0.0000
Wood	0.0013	0.0014	0.0033	0.0033	0.0015
Building Materials	0.0000	0.0000	0.0000	0.0000	0.0000
Machinery	0.0014	0.0015	0.0034	0.0034	0.0016
Miscellaneous	0.0008	0.0009	0.0020	0.0020	0.0009
Secondary	0.0000	0.0000	0.0000	0.0000	0.0000
Hazardous	0.0000	0.0000	0.0000	0.0000	0.0000
Government Land Use – Vehicle Trips Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0000	0.0000	0.0000	0.0000	0.0000
Raw Materials	0.0000	0.0000	0.0000	0.0000	0.0000
Food	0.0000	0.0000	0.0000	0.0000	0.0000
Textiles	0.0000	0.0000	0.0000	0.0000	0.0000
Wood	0.0001	0.0001	0.0001	0.0001	0.0001
Building Materials	0.0002	0.0002	0.0002	0.0002	0.0002
Machinery	0.0001	0.0001	0.0001	0.0001	0.0001
Miscellaneous	0.0002	0.0002	0.0002	0.0002	0.0002
Secondary	0.0000	0.0000	0.0000	0.0000	0.0000
Hazardous	0.0001	0.0001	0.0001	0.0001	0.0001

Table 5.21. Empty Vehicle Trip Rates.

Empty Vehicle Trip Rates – Productions					
Land Use	Area Type				
	1	2	3	4	5
Residential	0.0029	0.0029	0.0029	0.0029	0.0029
Industrial	0.0363	0.0669	0.1057	0.1057	0.0023
Retail	0.0107	0.0172	0.0064	0.0064	0.0346
Medical	0.0010	0.0009	0.0004	0.0004	0.0003
Office	0.0008	0.0050	0.0016	0.0016	0.0026
Education	0.0068	0.0072	0.0171	0.0171	0.0078
Government	0.0003	0.0003	0.0003	0.0003	0.0003
Empty Vehicle Trip Rates – Attractions					
Land Use	Area Type				
	1	2	3	4	5
Residential	0.0007	0.0007	0.0007	0.0007	0.0007
Industrial	0.0473	0.0871	0.1376	0.1376	0.0030
Retail	0.0065	0.0104	0.0039	0.0039	0.0208
Medical	0.0022	0.0019	0.0009	0.0009	0.0006
Office	0.0011	0.0073	0.0023	0.0023	0.0037
Education	0.0065	0.0069	0.0164	0.0164	0.0075
Government	0.0002	0.0002	0.0002	0.0002	0.0002

The TRIPCAL5 setups were structured to balance shipping totals to receiving totals. The reason for this was the initial trip rates used to develop these estimates were attraction rates and this was felt to represent to most reasonable estimate for both commodity movements and vehicle movements.

TRIPCAL5 was run using the demographic data for the HGA. Table 5.22 presents the results and the SAM estimates (see Tables 5.1 through 5.8). The total daily estimate from the SAM was 76,961 tons and the total daily estimate from the urban model was 318,974 tons. The percentages shown in Table 5.22 are not directly comparable because the SAM estimates did not include the miscellaneous and hazardous materials commodity groups.

Table 5.22. Daily Internal Commodity Estimates for SAM and Urban Model.

Commodity Group	SAM Estimate (tons)	Percent	Urban Model Estimate (tons)	Percent
Agriculture	85	0.11	1427	0.45
Raw Materials	39,978	51.94	110,580	34.67
Food	6248	8.12	22,194	6.96
Textiles	304	0.40	1869	0.59
Wood	2550	3.31	5560	1.74
Building Materials	11,246	14.61	136,161	42.68
Machinery	530	0.69	9336	2.93
Miscellaneous			26,034	8.16
Secondary	16,020	20.82	2867	0.90
Hazardous Materials			2946	0.92
Totals	76,961	100.00	318,974	100.00

EXTERNAL ESTIMATES

The estimation of external commodity movements is perhaps the most significant interface between the SAM results and the urban commodity model. The internal commodity movements from the SAM were estimated in the section titled “Top-Down” approach. This section discusses the procedures necessary to integrate the external related commodity movements into the urban commodity model. The procedures involve a number of different commodity movements which are discussed in the following sections. The term trip purpose in the following sections refers to the specific types of movements. These movements include II movements that begin and end in the HGA being modeled. EI movements are those movements that begin outside the HGA and end inside the HGA. IE movements are those that begin inside the HGA and end outside the HGA. EE through movements are those that begin outside the HGA, travel through the HGA, and end outside the HGA. EI, IE, and EE movements are also broken into those movements that involve just counties within Texas, those that involve the counties just outside Texas in neighboring states, and those that involve the external stations for the SAM.

SAM O-D Matrix (Truck Mode – Commodity Freight Flows)

O-D matrices (input data) for truck freight tons have dimensions 431 zones x 431 zones (254 counties in Texas, 35 counties in adjacent areas around Texas, and 135 SAM external stations that sums to a total of 431 zones being modeled) for each trip purpose. In SAM, the row or column dimensions reflect a bi-zonal structure, where the first layer zonal layer comprises of 254 Texas county centroids, and the second layer comprises of SAM external stations (142 SAM external stations and 35 external station county centroids). There are eleven such O-D matrices, one for each commodity group. The eleven commodity groups included in SAM are:

- agriculture,
- food,
- wood,
- textiles,
- building materials,
- machinery,
- chemicals and petroleum,
- raw materials,
- miscellaneous,
- secondary, and
- hazardous materials.

Note that no estimates were produced in SAM at the time of this research for the miscellaneous and hazardous material commodity groups. For each of these commodity groups, SAM estimates O-D matrices by trip purpose, where trip purpose is defined as SAM internal-internal (SAM-II), SAM external-internal (SAM-EI), SAM internal-external (SAM IE), and SAM external-external (SAM-EE).

Given the O-D matrix structure for the SAM, the SAM estimates of commodity movements are processed at the trip purpose level. The commodity flows that involve the urban area being

modeled (i.e., HGA) are identified within the SAM O-D matrix. The O-D matrix is then redefined for urban area analysis. Table 5.23 presents the matrix structure used to identify the commodity flows that relate to the HGA.

Redefined O-D Matrix for Urban Area (UA) Analysis

Redefining the O-D matrix is performed to facilitate a better mapping of SAM freight flows at the urban level in terms of zone delineation to identify flows for the various trip purposes. Table 5.24 shows the redefined O-D matrix structure for urban analysis respectively in the case of HGA and the pertinent partitions of the SAM OD matrix.

Table 5.23. Identifying Urban Area Flows in the SAM O-D Matrix.

Destination →		Inside Urban Area	Outside Urban Area		SAM Extrenal Stations
		HGA 8 Counties	Non-HGA TX Counties	Non-HGA, Outside TX	
Origins ↓					
Inside Urban Area	HGA eight Counties	SAM-II (HGAC-II)	SAM-II (HGAC-IE)	SAM-IE	
Outside Urban Area	Non-HGA TX Counties	SAM-II (HGAC-EI)	SAM-II (Through)	SAM-IE (Through)	
	Non-HGA Outside TX	SAM-EI	SAM-EI (Through)	SAM-EE (Through)	
SAM External Stations					

Table 5.24. Urban Area Analysis (HGA [Eight-CountyArea]).

	HGA	Non-HGA	SAM Ext-Stations
HGA (eight counties)	UA-II (SAM-II)	UA-IE (SAM II)	SAM-IE
All other TX counties (Non-HGA)	UA-EI (SAM-II)	UA-Through (SAM II)	UA-Through (SAM IE)
SAM EXT-Stations	UA-SAM EI	UA-Through (SAM EI)	UA-Through (SAM EE)

Urban Area Internal-Internal, Internal-External, and External-Internal Flows

Table 5.25 shows the commodity flow volumes for one commodity group, Agriculture, that need to be extracted from SAM O/D II Matrix for the eight HGA counties in order to develop urban area II flows, IE, and EI flows. Table 5.25 indicates agricultural annual commodity freight flow volumes equal to 31,076 coming into the HGA (eight-county) urban area. These freight-flow volumes are the flows that are internal to the eight-county area that were disaggregated in the “Top-Down” estimates section of this Chapter. Figure 5.1 shows the flow chart procedure for extracting different flows by trip purpose (II, IE, EI) for each commodity group for the HGA from SAM O-D matrices. This procedure is easily generalizable to other urban areas.

Due to the SAM zonal structure, urban area EI flows have two components: 1) those outbound from SAM external stations (SAM EI, IE) to the region and, 2) those inbound to the urban region from other regions or areas within the state. The same applies to urban area IE flows.

Urban Area Through Flows

Similar to urban area IE and EI flows, flows going through the urban area are comprised of four components from SAM (Table 5.23). Figures 5.2 to 5.5 depict these flows graphically. Through movements coming into the region can only be identified via a SAM critical link analysis (CLA). This CLA is also necessary to develop EI and IE commodity movement tables for modeling purposes. The following sections discuss the processes necessary to perform a critical link analysis using TransCAD. It is assumed the reader is familiar with this software package since it is used by The Texas Department of Transportation for travel demand modeling both for urban areas and in the SAM.

Table 5.25. Example of HGA Urban Area II Agriculture Commodity Flow Estimates from the SAM.

SAM		SAM_AGri_Intrastate Flows (I/I)					SAM_AGri_Intrastate Flows_HGAC_13County_not in TDM area(5)					SAM_AGri_Intrastate Flows_HGAC_8County TDM Area				
		County Codes					County Codes					County Codes				
O-D	Other non HGA counties	48321	48471	48481	48015	48089	48039	48071	48157	48167	48201	48291	48339	48473		
		0	0	0	0	0	0	0	0	0	0	0	0	0		
48321		0	0	0	0	0	0	0	0	0	0	0	0	0		
48471		0	0	0	0	0	0	0	0	0	0	0	0	0		
48481		0	0	0	0	0	0	0	0	6.16	0	0	0	0		
48015		0	0	0	0	0	0	0	0	16.01	0	0	0	0		
48089		0	0	0	0	0	0	0	0	0	0	0	0	0		
48039		0	0	0	0	0	0	0	0	17,660	87	0	0	0		
48071		0	0	0	0	0	0	0	0	0	0	0	0	0		
48157		0	0	0	0	0	0	0	0	0	0	0	0	0		
48167		0	0	0	0	0	0	0	0	9318	43	0	0	0		
48201		0	0	0	0	0	0	0	0	3663	17	0	0	0		
48291		0	0	0	0	0	0	0	0	0	0	0	0	0		
48339		0	0	0	0	0	0	0	0	0	288	0	0	0		
48473		0	0	0	0	0	0	0	0	0	0	0	0	0		
		Column totals					0	0	0	0	30,929	147	0	0		
		Row Totals					17,747	0	0	9361	3680	0	0	288	31,076	

These would be EI flows to HGAC Urban Area

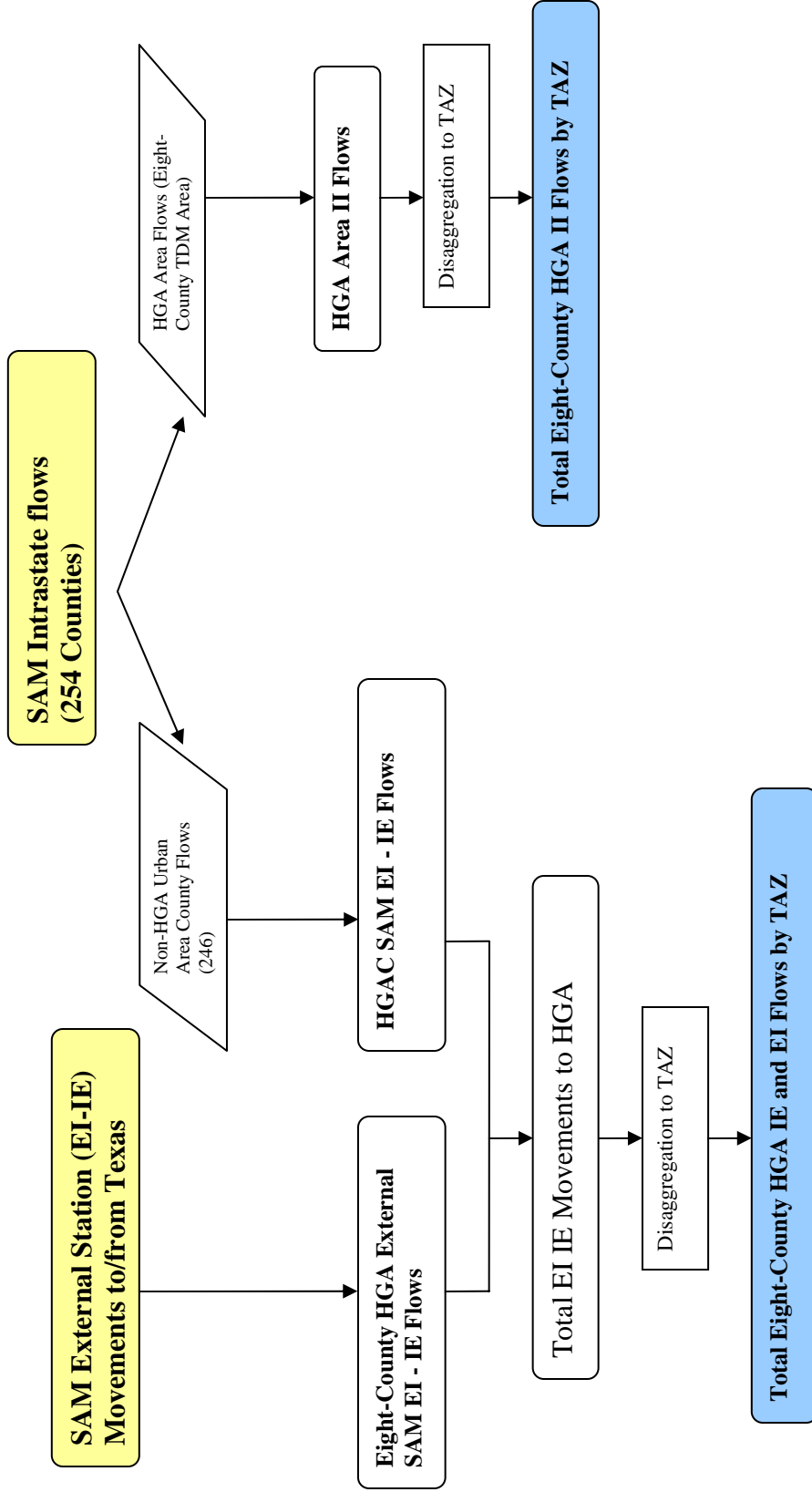


Figure 5.1. SAM Flows and Urban Interface (HGA IE, EI, and II).

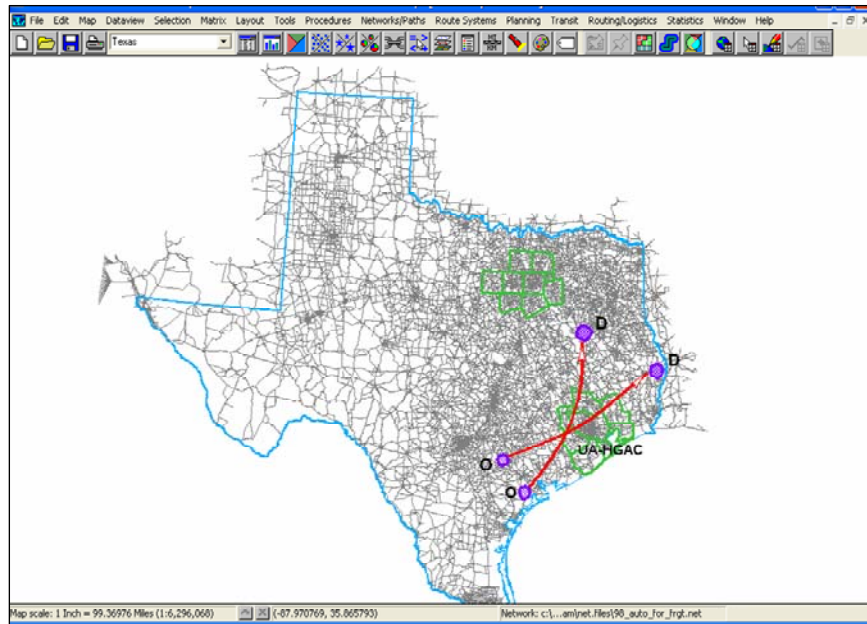


Figure 5.2. Urban Through Movement Occurring from SAM-II.

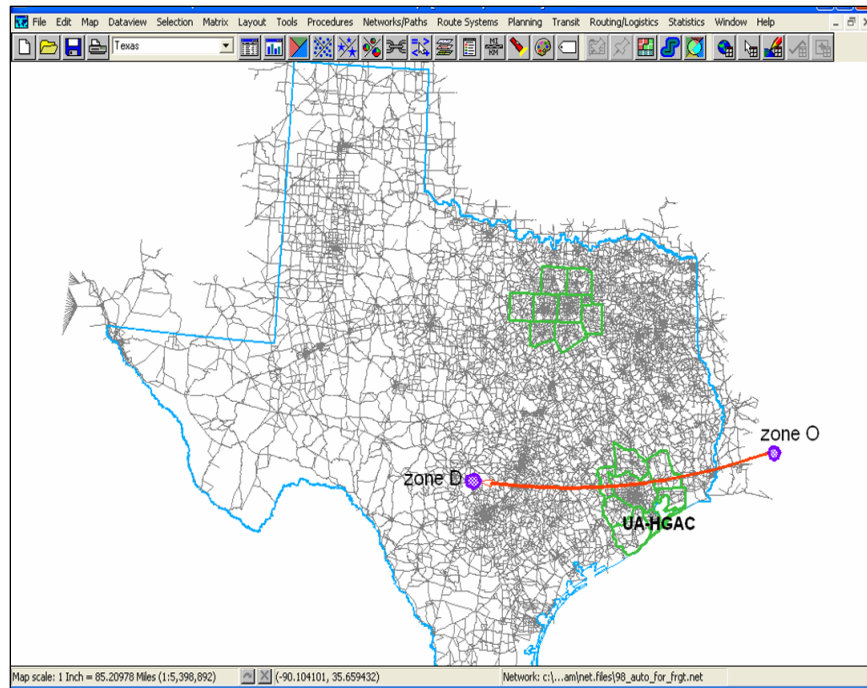


Figure 5.3. Urban Through Movement Occurring from SAM-EI.

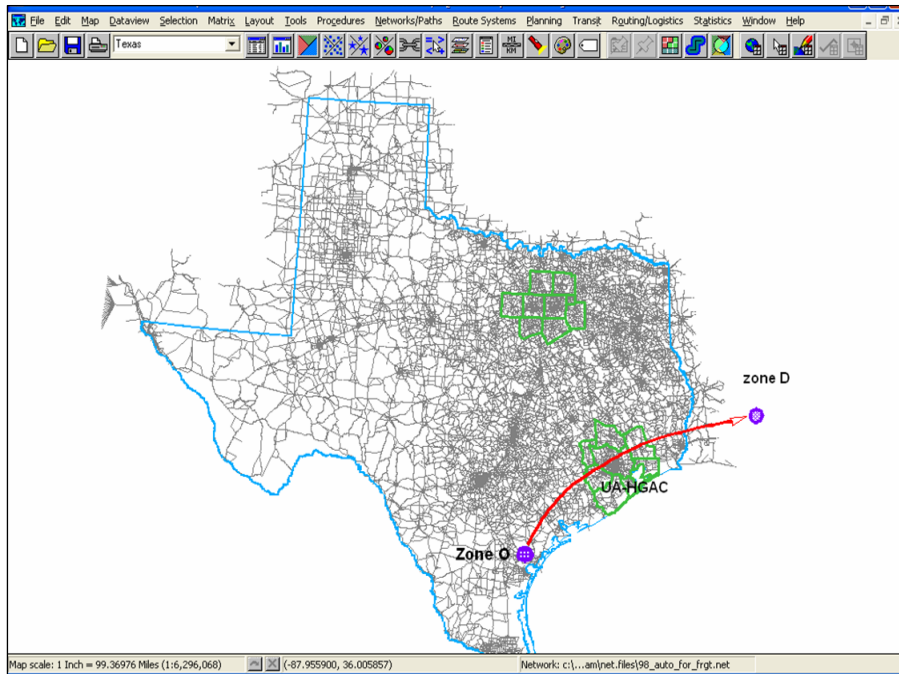


Figure 5.4. Urban Through Movement Occurring from SAM-IE.

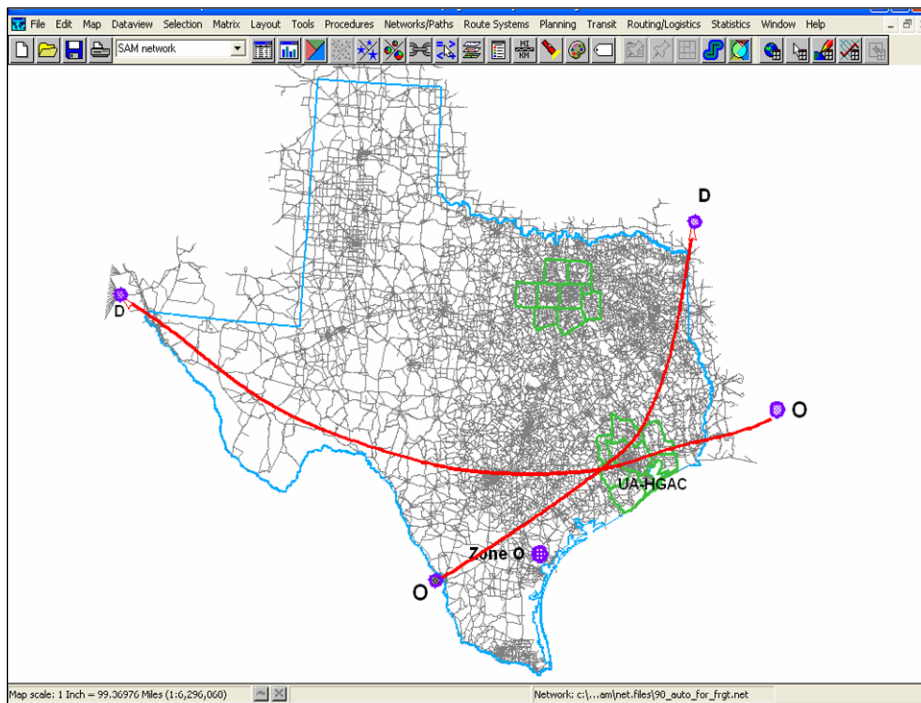


Figure 5.5. Urban Through Movement Occurring from SAM-EE.

Procedure for Critical Link Analysis

The critical link analysis consists of three phases; 1) pre-steps, 2) steps for CLA, and 3) steps for running CLA. In general, simple examples with these steps are found in TransCAD manual (*Travel Demand Modeling with TransCAD*) or in similar operational documents using TransCAD. In addition to three phases, one additional step for converting the output is presented in order to redeem the output into non-matrix form. The critical link analysis is an optional output from trip assignment which reports in a form of matrix the origins and destinations of trips passing the links selected. Critical link matrices result from this optional output, and the number of critical link matrices depends on how many different link names are specified based on selected links. However, when focusing on a metropolitan planning area boundary, the critical links that are identified should be specified in a bi-directional way. This identification is a key point to make the critical link set for “Ins” to inbound direction and for “Outs” to outbound direction based on a bi-directional network. Resulting critical link matrices capture complete “Non-Through” commodity movements for a metropolitan planning area, while “Through” commodity movements are double-counted at the boundary of the metropolitan planning area.

Phase 1: Pre-Steps

This phase is essential for understanding TransCAD map and for identifying both network structure and zone structure indicated by centroids and external stations. Fundamental steps for the selection of HGA are:

- Step 1. Open SAM master network. See Figure 5.6.

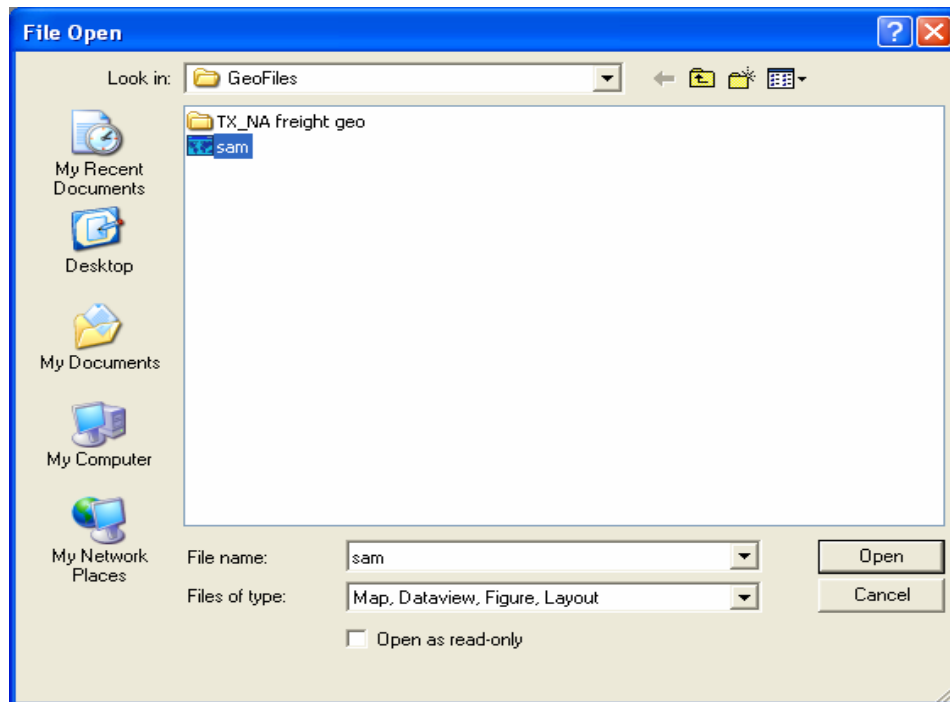


Figure 5.6. Open File Screen.

Step 2. Click on Show Layer for SAM net endpoints (node layer) to select centroids. Selected centroids are used for a county level freight assignment. There are 431 SAM centroids. To select centroids, choose *Map-Layers* and click *Show Layer* button. The following screen, Figure 5.7, appears. Click *Close* button when viewing is complete.

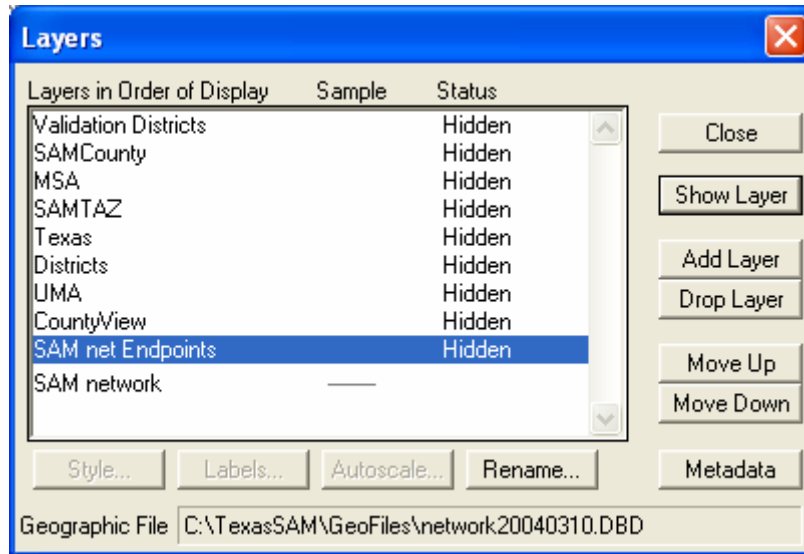


Figure 5.7. Map Layers.

Choose *SAM net Endpoints* from the drop-down list of layers on the toolbar. Choose *Selection-Setting* and click *Add Set* button on SAM net Endpoints Selection Sets, and then rename it as centroids, (see Figure 5.8).

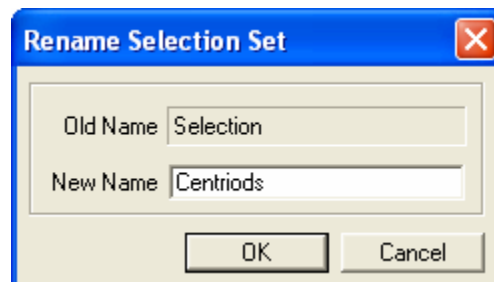


Figure 5.8. Rename Selection Set.

Since endpoint IDs include centroids and external stations, the selection condition is as follows and is shown in Figure 5.9, i.e., $ID \geq 48001$ and $ID \leq 48507$ or $ID \geq 4601$ and $ID \leq 4742$.

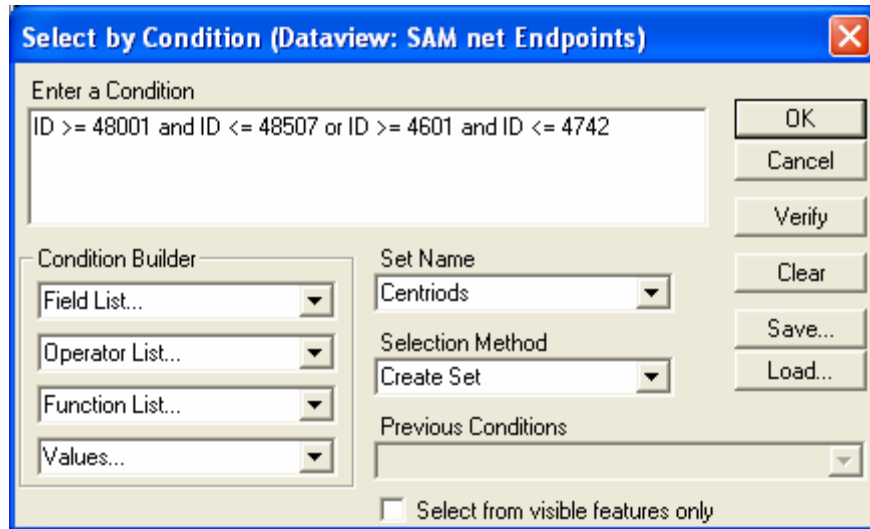


Figure 5.9. Select by Condition for Centroids.

Selection by condition displays SAM map with centroids as shown below in Figure 5.10.

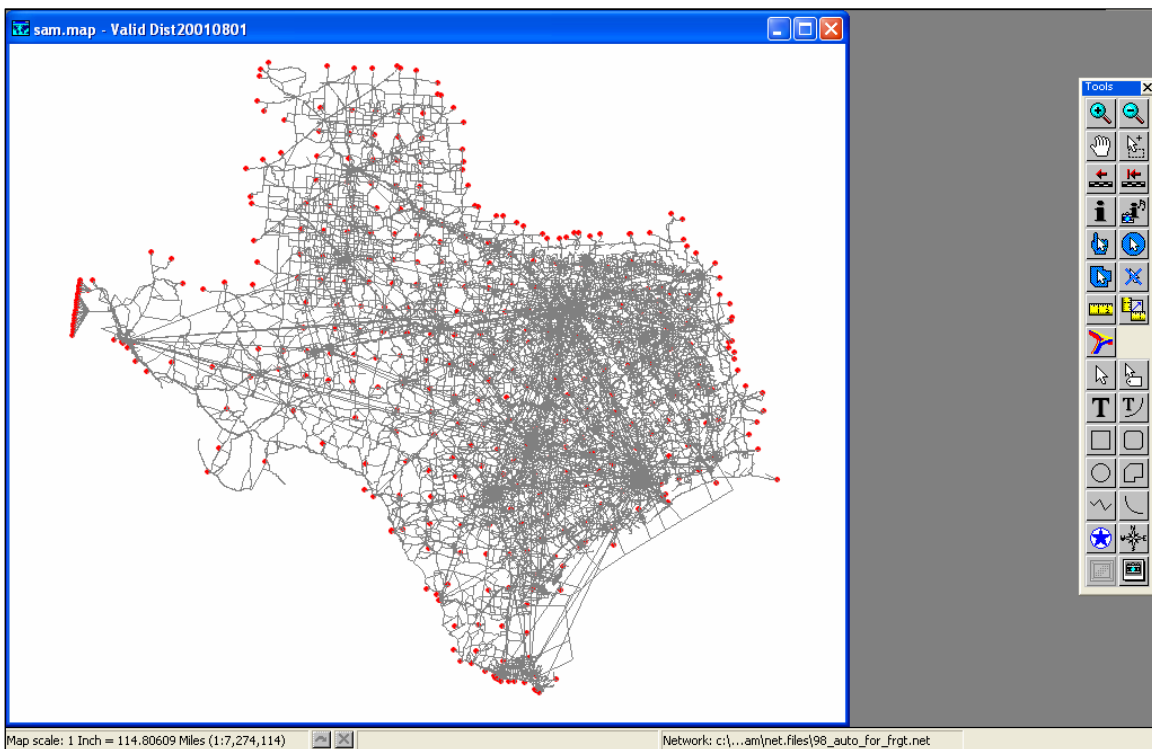


Figure 5.10. SAM Network Map with Centroids.

Step 3. Choose **Map-Layers** and click on **Show Layer** for SAM County to select counties in the HGA (or any other urban area, North Central Texas Council of Governments [NCTCOG] is also shown in this report).

- a. HGA: (FIPS =48039 | FIPS =48071 | FIPS =48157 | FIPS =48167 | FIPS =48201 | FIPS =48291 | FIPS =48339 | FIPS =48473)
- b. NCTCOG: (FIPS =48085 | FIPS =48113 | FIPS =48121 | FIPS =48139 | FIPS =48251 | FIPS =48257 | FIPS =48367 | FIPS =48397 | FIPS =48439)

To select HGA counties, choose **Map-Layers** and click **Show Layer** button. Click **Close** button. SAM counties will be displayed.

Choose **SAM County** from the drop-down list (see Figure 5.11) and go to **Selection-Setting** and click **Add Set** on SAM County Selection Sets, and then rename it as HGA (see Figure 5.12).

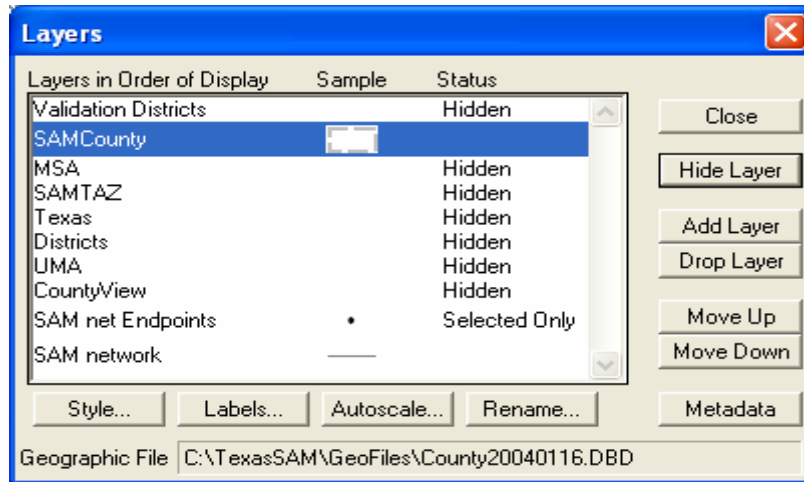


Figure 5.11. Show Layer for SAM County.

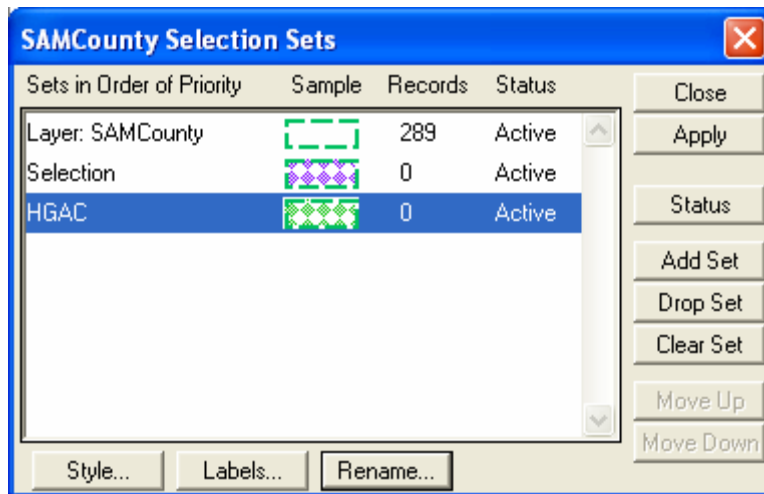


Figure 5.12. SAM County Selection Sets.

Type a condition to select HGA counties and set name to HGA created (see Figure 5.13). Then click **OK**. This selection (HGA counties) is activated. To make it visible only, it is necessary to make SAM County invisible.

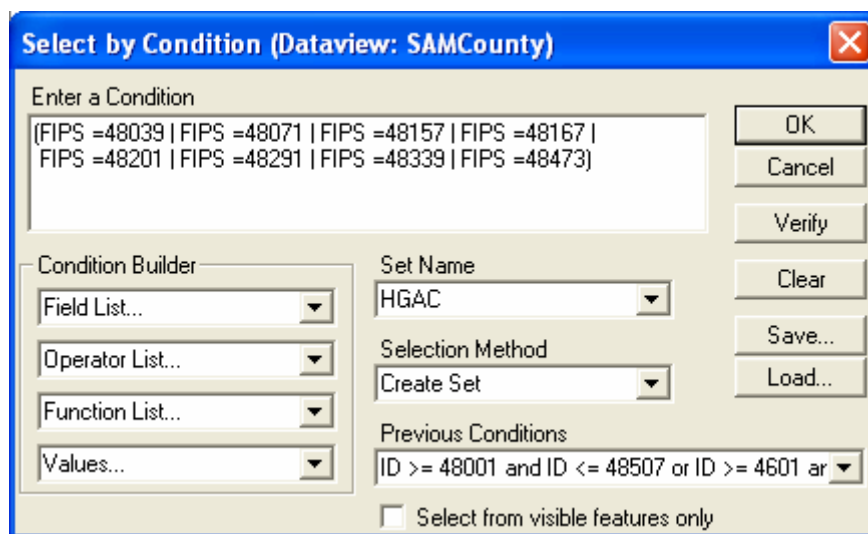


Figure 5.13. Selection by Condition for HGA Counties.

Go to *Selection-Settings* and make sure to click *Status* button in order to make the layer (SAM County) invisible as shown below. Only HGA counties will be displayed as shown in Figure 5.14. Figure 5.15 shows the urban area boundary within the SAM network file.

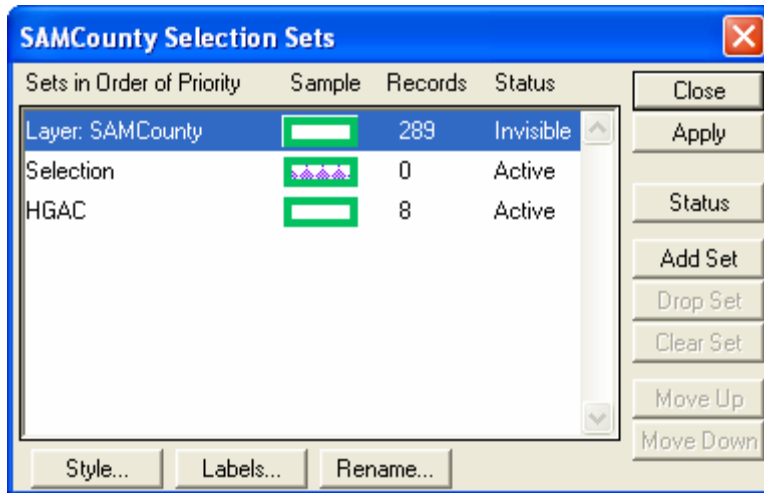


Figure 5.14. HGA Selection Set.

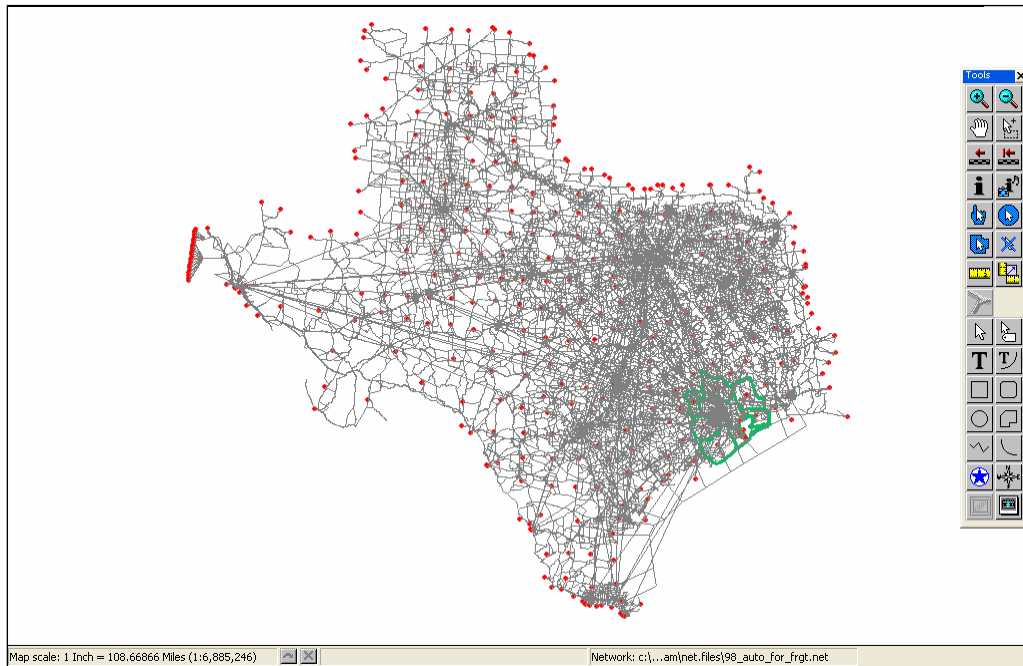


Figure 5.15. SAM Network and HGA Area.

The same procedure may be applied to display other study areas. For example, Figure 5.16 shows the HGA and NCTCOG study areas. Numbers along the boundary of State of Texas are SAM external stations and represent counties adjacent to the state in bordering states.

Step 4. Identify critical links located along the HGA urban boundary from .png files which show the location of urban area external stations. From png files and SAM roadway network, 41 critical links are identified (38 critical links on roadway and 3 critical links on seaport). Table 5.26 lists the external stations for the HGA that are referred to as the critical links and Figure 5.17 shows their location.

Table 5.26. Critical Links for HGA Urban Boundary.

Number	Link ID	Facility
1	2786724	IH10E
2	2021245	IH10W
3	2140276	IH45N
4	2016138	UA90W
5	2035480	US290
6	2227744	US59NE
7	2015112	US59W
8	2248048	US90E
9	2244095	SH105E
10	2076508	SH105W
11	2288395	SH146
12	2035605	SH159
13	1989019	SH35
14	2017120	SH36
15	2043369	SH6
16	2786603	SH73
17	2140416	SH75
18	2786242	SH87E
19	2133338	FM149
20	2265940	FM223
21	2044427	FM362
22	1991296	FM442
23	1992837	FM521
24	2034924	FM529
25	2243935	FM770
26	2288952	FM787
27	2020370	FM1093
28	2250927	FM1097
29	1990990	FM1301
30	2138991	FM1375
31	2786620	FM1406N
32	2237605	FM1406S
33	2133163	FM1486
34	2226204	FM1725
35	2075822	FM1774
36	2134565	FM1791
37	2226388	FM2025
38	1992183	FM2611
39	2206506	CP (Texas City Port)
40	2202756	HP (Houston Port)
41	2005845	GP (Galveston Port)

Note: UA = Urban Area.

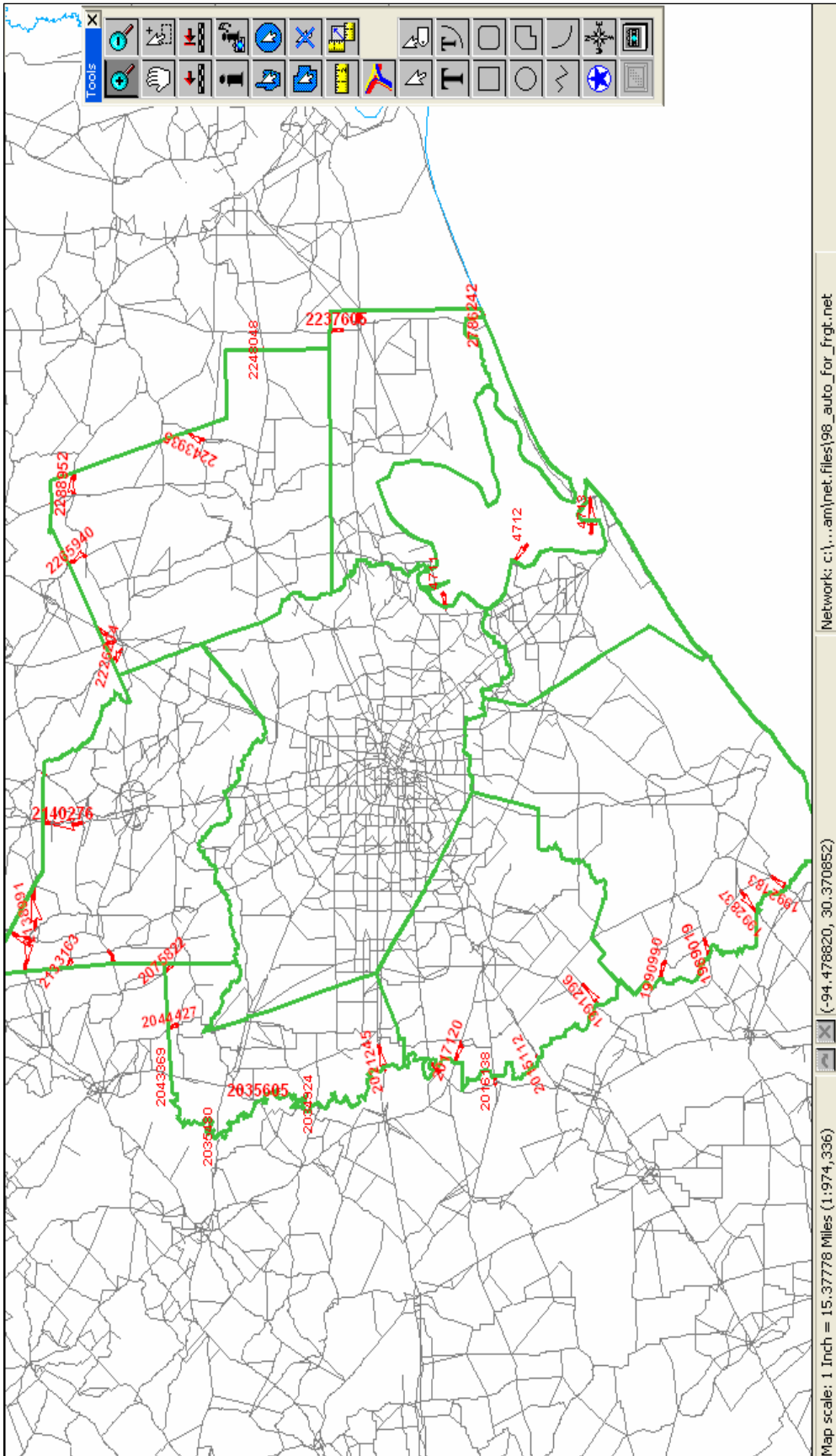


Figure 5.17. Critical Links along HGA Urban Boundary.

Step 5. Identify each node (endpoints – from and to) from all critical links and display it (see Figure 5.18). This is a critical step because it is important to find the node points and match them to the critical links. Based on this, two sets of critical link tables may be established inbound and outbound to HGA urban boundary.

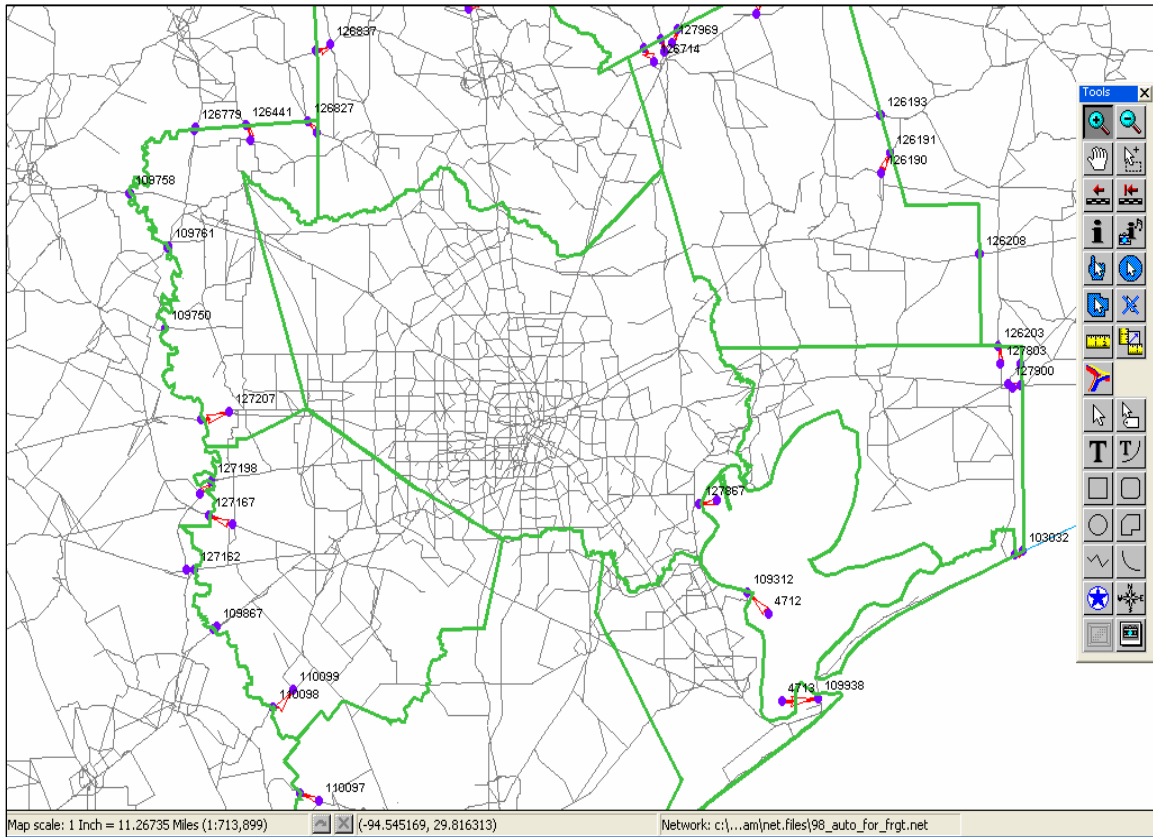


Figure 5.18. Endpoints of Critical Links along HGA Urban Boundary.

Phase 2: Steps for Critical Link Analysis (CLA)

Three steps are included in this phase; create network (.net), check input data (EE, IE, EI and II), and create critical link sets. These are the three key input requirements for the CLA routine.

Create Network (.net) for Assigning Truck Freight Volumes

TransCAD has a special data structure with a network defined as a set of nodes and links. It also uses geographic files to make maps of transportation systems and the network to solve transportation problems such as routing, mode choice, and trip assignment. Hence, it is crucial to create a network that includes the line layer, features and fields you want to use for such purposes. In this case, the .net file for running the trip assignment with CLA as an option must be created. This file can be used for all urban areas and is not specific to HGA.

Since the current SAM network is the master network, specific fields should be selected for creating a network for freight distribution. These fields are *Mode_Code*, *New_Link_Flag*, and *FreightCenBool*. According to the *Texas Statewide Analysis Model: Operator's Manual (79)*, the *Mode_Code* attribute is used to identify what modes of travel are allowed on a link. Table 5.27 shows the mode_code legend (79). In this case, since truck-based commodity freight is being assigned, the mode code selected is 10. For other cases like rail/air, new networks need to be created with their specific mode codes selected.

Table 5.27. Mode Code Legend.

Mode_Code	Mode of Transportation
0	Various Minor Freight Related Connectors
10	Roadway
21	Passenger Rail
31	Commercial Rail
40	Airways
51	Rail To Intermodal Connection
52	Intermodal to Roadway Connection
53	Rail to Passenger Connection
54	Station to Roadway Connection
55	Air Terminal to Roadway Connection
56	Port to Roadway Connection
60	Waterway
65	Waterway to Port Connector
80	High Speed Rail
85	High Speed Rail to Roadway Connector

The *New_Link_Flag* is used to identify the year that the network link will be made active (79). Table 5.28 shows the legend for the *New_Link_Flag*.

Table 5.28: New Link Flag Legend.

New_Link_Flag	Description of Flag
-2	Link not in official networks
-1	Link in 1998 but deleted in 2025
0	Link in both 1998 and 2025
1	New link in 2025. Not in 1998

The *FreightCenBool* attribute will contain a “1” where the link is required for a county-level freight procedure. The process to set these fields is:

- a. Choose *Selection-Settings*.
Click *Add Set* and then rename it as <98_Auto_for_Frgt>
Choose *Selection-Select by Condition*.
Type the condition: (MODE_CODE=10 & (NEW_LINK_Flag = -1 |
NEW_LINK_Flag = 0)) | FreightCenBool = 1
Set name to <98_Auto_for_Frgt>.

Figure 5.19 shows an example of this.

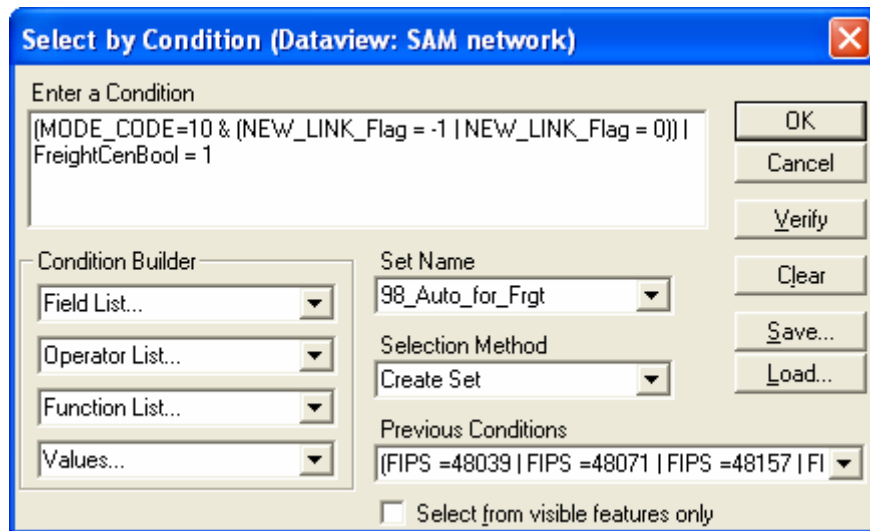


Figure 5.19. Selection by Condition for Creating Network.

Choose SAM network from the drop-down list and choose *Selection-Settings*. Selection set for 98_Auto_for_Frgt will be displayed as shown in Figure 5.20.

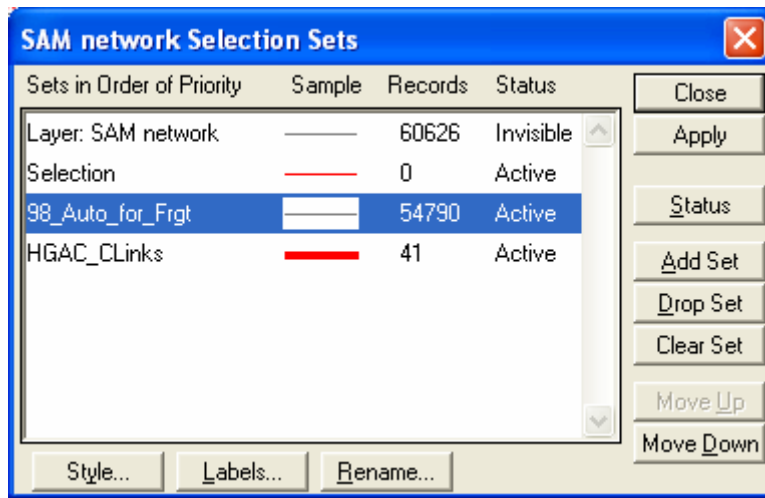


Figure 5.20. SAM Network Selection Sets for 98_Auto_for_Frgt.

- b. Choose *Networks/Paths–Create* (see Figure 5.21).
Choose the features to include: Create links from 98_Auto_for_Frgt.
Choose the field with length data: Read length from Length.
Choose optional link fields: Length, Time, TimeFrgt X_Capacity98.
Choose options.
Save as Network: 98_Auto_for_Frgt.net.

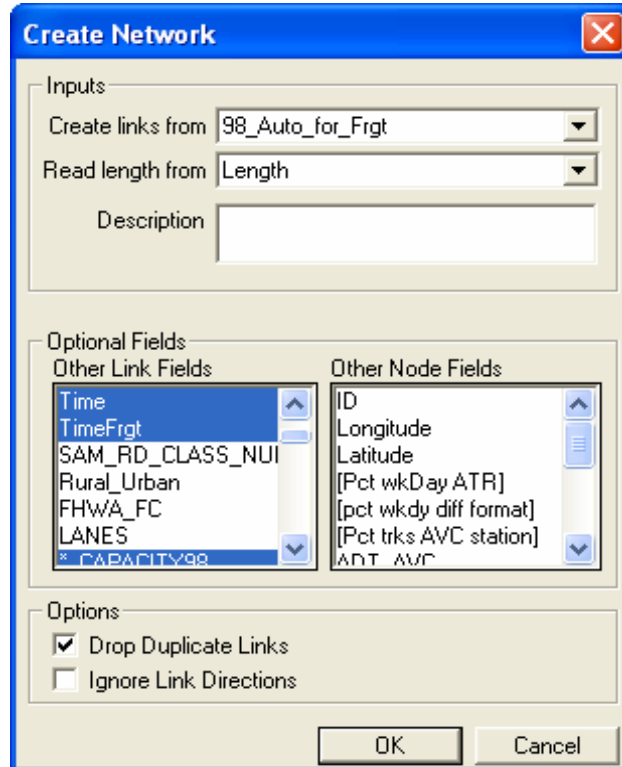


Figure 5.21. Create Network.

- d. Choose *Networks/Paths-Settings* (see Figure 5.22).
 Check network fields and general information about the network.
 Click options for centroids and then click other settings:
 Centroids are in network.
 Click OK.

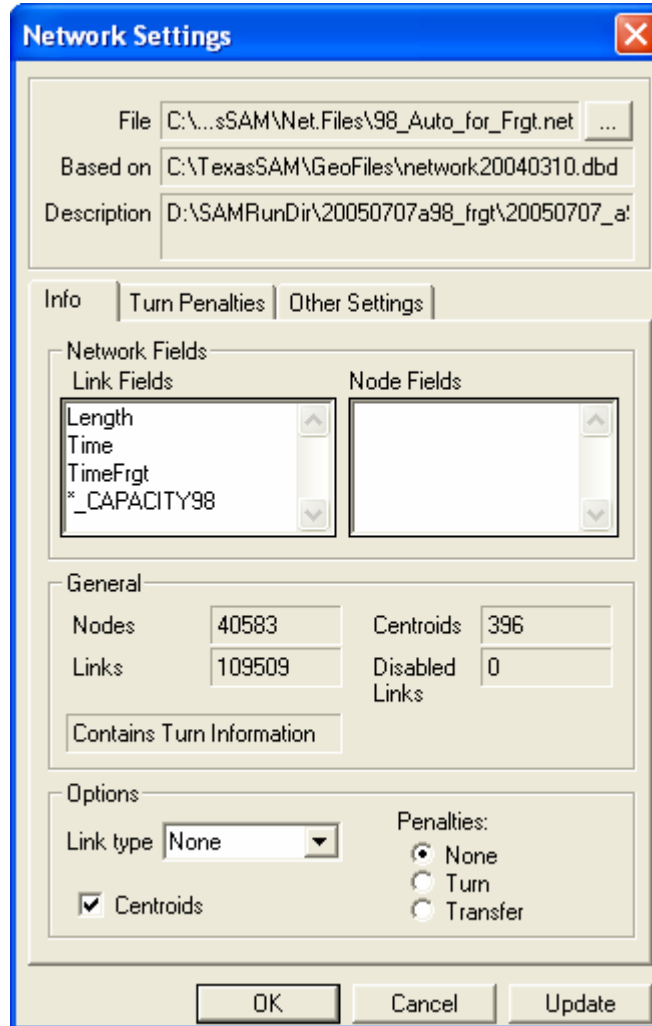


Figure 5.22. Network Settings.

Check Input Data (O-D Matrix)

In this operation, truck freight tons are considered for nine of the eleven commodity groups and for all trip purposes (EI, IE, II, and external through) as inputs (miscellaneous and hazard are excluded).

Create Truck Tons Total file. To use the data as input for trips assignment, every separate file should be combined by trip purpose and commodity groups (SAM-EE by commodity, SAM-IE by commodity, SAM-EI by commodity, and SAM-II by commodity). Create the following files shown in Table 5.29. For the purpose of this report, the 9_commodity.mtx file was used for assignment since this represents the combination of all trip purposes and commodity groups.

Table 5.29. Input Data Combined.

File name (.mtx) by commodity	File name (.mtx) for Total_TruckTons	Comments
9_commodity	Total_TruckTons	This file is used for HGA urban CLA. This includes nine matrices, one for each commodity group.
EE_by_9_commodity	Total_TruckTons_for_EE	Can be used on a stand-alone basis if only interested in identifying SAM through flows
EI_by_9_commodity	Total_TruckTons_for_EI	
IE_by_9_commodity	Total_TruckTons_for_IE	
II_by_9_commodity	Total_TruckTons_for_II	

Critical Link Set Table

Assign a unique name to each critical link. Sets of critical links must be specified in a data table. A unique name for each set must be assigned (one name for one set). Since HGA has 41 critical links along the urban area boundary, link-specific names must be given to each link to be able to identify link-specific volumes.

Identify *From_Node* and *To_Node* for every critical link. Every link is bi-directional (assumed) and has a topological direction which is displayed with an arrow (A_B Flow) as a default. Based on the HGA urban boundary, the link is identified as inbound if topological direction is coming into the urban area boundary and as outbound if topological direction is going out of the cordon. These directions will be identified as AB flows or BA flows in the ASN_Linkflow.bin file (which is one of the outputs from the CLA).

Create two sets of critical link tables- Ins-set and Outs-set. It is important to match end points to critical links. Create the ins-critical link table. Next, the outs-critical link table can be created by flipping over *From_Node* and *To_Node*. Tables 5.30 and 5.31 oresetb the Ins and Outs critical link set table for HGA.

Summary of Key Input Files for CLA

Three input files required for the critical link analysis are **1) a network (.net) file with the appropriate attribute fields, 2) input data as O-D matrix, and 3) critical link set table.** The network file is defined and derived from the line layer. The critical link analysis along urban boundary requires two sets of critical link tables (Ins-set and Outs-set).

Table 5.30. Ins-Critical Link Table for HGA.

Number	ID	LINK	FROM_NODE	TO_NODE	Facility
1	2786724	2786724	103040	103038	IH10E
2	2021245	2021245	127204	127207	IH10W
3	2140276	2140276	127065	127031	IH45N
4	2016138	2016138	109855	127162	UA90W
5	2035480	2035480	109758	109757	US290
6	2227744	2227744	126990	127969	US59NE
7	2015112	2015112	109866	109867	US59W
8	2248048	2248048	126208	126207	US90E
9	2244095	2244095	126193	126192	SH105E
10	2076508	2076508	126836	126837	SH105W
11	2288395	2288395	126515	126513	SH146
12	2035605	2035605	109760	109761	SH159
13	1989019	1989019	124535	124537	SH35
14	2017120	2017120	127167	127157	SH36
15	2043369	2043369	126779	126778	SH6
16	2786603	2786603	103034	127900	SH73
17	2140416	2140416	127038	127066	SH75
18	2786242	2786242	103032	103031	SH87E
19	2133338	2133338	127727	127731	FM149
20	2265940	2265940	128346	126508	FM223
21	2044427	2044427	126441	126440	FM362
22	1991296	1991296	110098	110099	FM442
23	1992837	1992837	124486	124485	FM521
24	2034924	2034924	109749	109750	FM529
25	2243935	2243935	126191	126190	FM770
26	2288952	2288952	126527	126512	FM787
27	2020370	2020370	127196	127198	FM1093
28	2250927	2250927	126233	126232	FM1097
29	1990990	1990990	110096	110097	FM1301
30	2138991	2138991	127059	127058	FM1375
31	2786620	2786620	103034	103036	FM1406N
32	2237605	2237605	126203	127803	FM1406S
33	2133163	2133163	124721	127728	FM1486
34	2226204	2226204	126720	126714	FM1725
35	2075822	2075822	126827	126826	FM1774
36	2134565	2134565	127461	127731	FM1791
37	2226388	2226388	126723	126722	FM2025
38	1992183	1992183	110113	110114	FM2611
39	2206506	2206506	4711	127867	CP*
40	2202756	2202756	4712	109312	HP*
41	2005845	2005845	4713	109938	GP*

* CP = Texas City Port, GP = Galveston Port, and HP = Houston Port.

Table 5.31. Outs-Critical Link Table for HGA.

Number	ID	LINK	FROM_NODE	TO_NODE	SET
1	2786724	2786724	103038	103040	IH10E
2	2021245	2021245	127207	127204	IH10W
3	2140276	2140276	127031	127065	IH45N
4	2016138	2016138	127162	109855	UA90W
5	2035480	2035480	109757	109758	US290
6	2227744	2227744	127969	126990	US59NE
7	2015112	2015112	109867	109866	US59W
8	2248048	2248048	126207	126208	US90E
9	2244095	2244095	126192	126193	SH105E
10	2076508	2076508	126837	126836	SH105W
11	2288395	2288395	126513	126515	SH146
12	2035605	2035605	109761	109760	SH159
13	1989019	1989019	124537	124535	SH35
14	2017120	2017120	127157	127167	SH36
15	2043369	2043369	126778	126779	SH6
16	2786603	2786603	127900	103034	SH73
17	2140416	2140416	127066	127038	SH75
18	2786242	2786242	103031	103032	SH87E
19	2133338	2133338	127731	127727	FM149
20	2265940	2265940	126508	128346	FM223
21	2044427	2044427	126440	126441	FM362
22	1991296	1991296	110099	110098	FM442
23	1992837	1992837	124485	124486	FM521
24	2034924	2034924	109750	109749	FM529
25	2243935	2243935	126190	126191	FM770
26	2288952	2288952	126512	126527	FM787
27	2020370	2020370	127198	127196	FM1093
28	2250927	2250927	126232	126233	FM1097
29	1990990	1990990	110097	110096	FM1301
30	2138991	2138991	127058	127059	FM1375
31	2786620	2786620	103036	103034	FM1406N
32	2237605	2237605	127803	126203	FM1406S
33	2133163	2133163	127728	124721	FM1486
34	2226204	2226204	126714	126720	FM1725
35	2075822	2075822	126826	126827	FM1774
36	2134565	2134565	127731	127461	FM1791
37	2226388	2226388	126722	126723	FM2025
38	1992183	1992183	110114	110113	FM2611
39	2206506	2206506	127867	4711	CP
40	2202756	2202756	109312	4712	HP
41	2005845	2005845	109938	4713	GP

Phase 3: Steps for Running the CLA

The first step is to assign truck freight input data by commodity using the required network attributes and assignment settings. The “all-or-nothing” assignment method was used to run the CLA. The required network attribute for an all-or-nothing assignment is **Time**. The all-or-nothing assignment does not require any settings such as iteration, convergence, α and β . To run the CLA in TransCAD, open three files on the screen, SAM network, input data, and critical link set table. These files may also be saved as a work file.

Since the input data (truck tons in agriculture) are assigned to the critical links as inbound, open the following three files and make SAM map active on screen (see Figure 5.23).

- (1) SAM map (sam)
- (2) input data (9_commodity.mtx)
- (3) critical link set table (HGA_link_ins_AG.dbf)

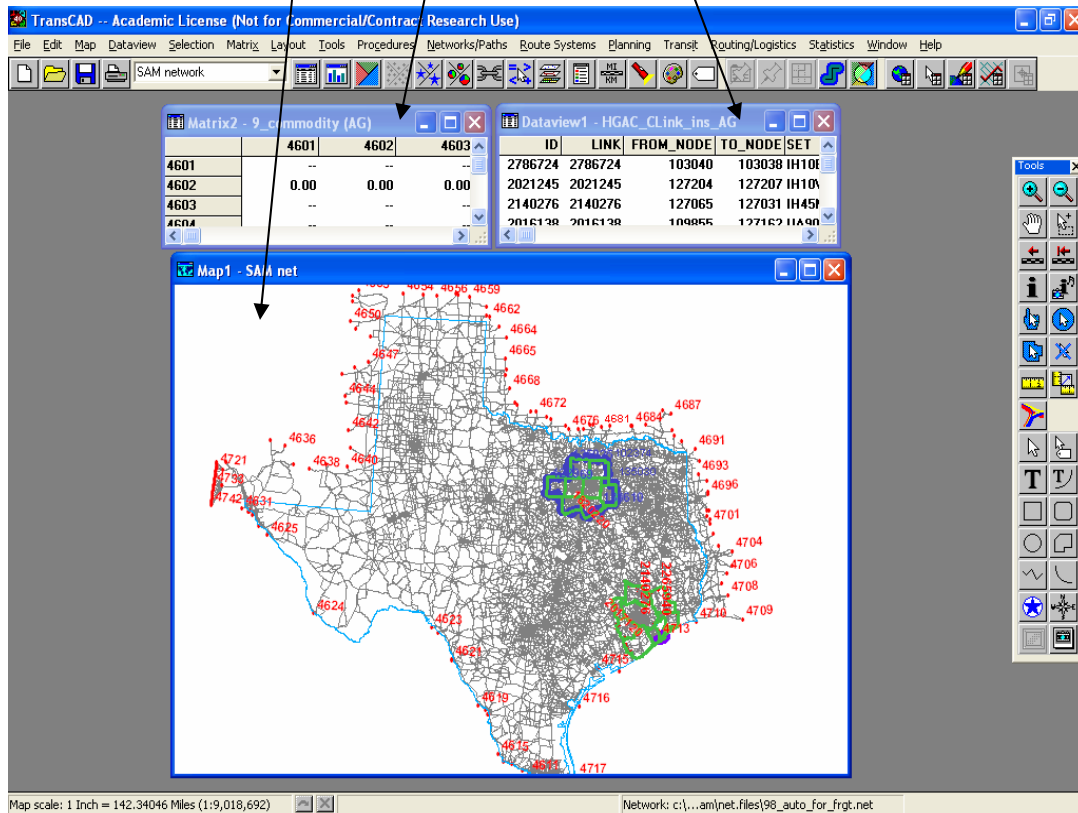


Figure 5.23. Three Files Required for Running the CLA.

After opening the three files, choose > **Planning-Traffic Assignment**. Then, check the chosen fields and options required for running the critical link analysis.

a. Check the fields as shown in Figure 5.24.

Line layer: SAM network

Network File: c:\...\...\98_Auto_for_Frgt.net

Method: All or Nothing

Matrix File (input data): 9_commodity

Matrix: AG

Fields: Time

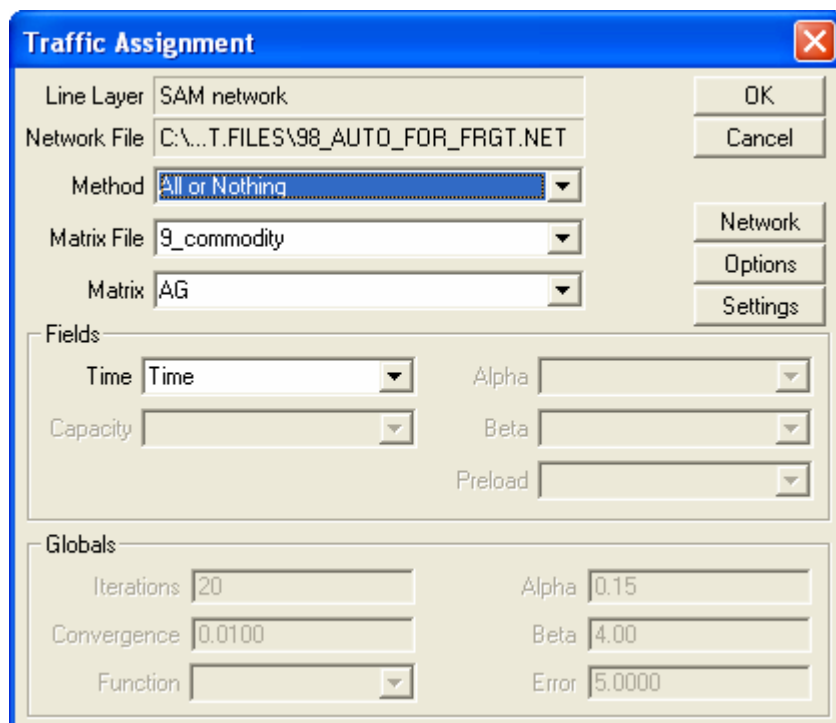


Figure 5.24. Checking Fields in Trip Assignment.

Click **Options** button and choose HGAC_Clink_ins_AG from the **Table** drop-down list in Figure 5.25.

Highlight all critical link sets in the **Sets** scroll list in Figure 5.25.

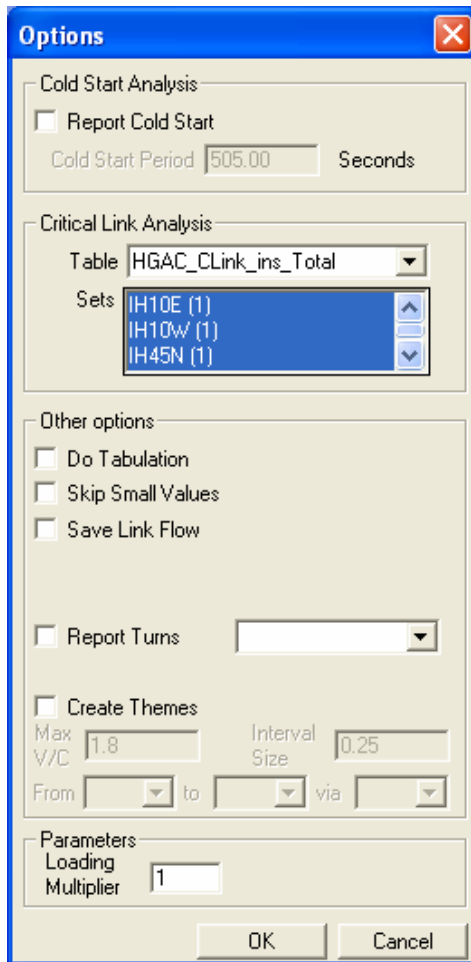


Figure 5.25. Highlight All the Critical Links.

Click OK to return to the *Traffic Assignment* dialog box.

Click OK to display the *Output File Settings*.

Highlight *Flow Table* in Figure 5.26, and click *Save As*. Type “ASN_CRITICAL_ins_AG” as the file name and click *Save*.

Highlight *Critical Matrix* in Figure 5.26, and click *Save As*, type “ASN_LINKFLOW_AG” as the file name and click *Save*.

Click OK.

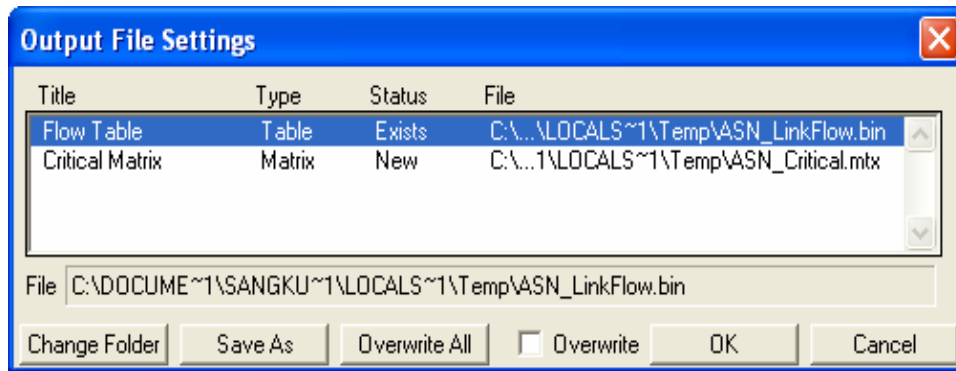


Figure 5.26. Output File Settings.

The above procedure produces a flow table and a critical link matrix file with as many matrices as the number of highlighted critical link sets. In the case of HGA with 41 critical links as inbound for agricultural commodity, the CLA produces 41 inbound critical link matrices. Also 41 outbound critical link matrices are created for the same commodity. For 9 commodity groups, a total of 738 (41 critical links × 9 commodities × 2 directions) matrices are created for both inbound and outbound.

The above steps must be done repeatedly for each work file with a combination of commodity and critical link set table (Ins-set and Outs-set). By running 18 work files 738 critical matrices are created that must be combined into one file. This procedure is time-intensive and the process can be more efficient by using a batch macro in GISDK. A series of batch macro files for the CLA for HGA were coded and are shown in Appendix D. These files were run in GISDK Toolbox (see Figure 5.27).

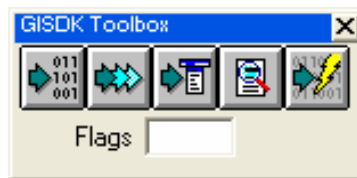


Figure 5.27. GISDK Toolbox.

Click the above first left button, and go to the directory with the batch macro files. There are 12 batch macro files in the directory (Figure 5.28). Running all batch macro files in sequential order as shown in Table 5.32 gives the final critical link matrices. It takes about 40 minutes. Number 1 is a batch macro file to run the CLA and other files (numbers 2~12) are files to combine matrices created by number 1. Running number 12 gives the final output as follows.

Final output for HGA

ASN_CRITICAL_HGAC(41CLINKS and 9COMM).mtx

ASN_LINKFLOW_INS_TOTAL.bin

ASN_LINKFLOW_OUTS_TOTAL.bin

Table 5.32. Batch Macro Files.

Sequential Number #	File Name	Comment
1	HGAC_CLA_9comm_ins_outs Total_ins_outs	Run the CLA
2	Mat_Summations_Ins&Outs_01_AG	Matrix combine by commodity: Ins- and Outs- matrices.
3	Mat_Summations_Ins&Outs_02_BM	
4	Mat_Summations_Ins&Outs_03_CP	
5	Mat_Summations_Ins&Outs_04_FD	
6	Mat_Summations_Ins&Outs_05_MA	
7	Mat_Summations_Ins&Outs_06_RM	
8	Mat_Summations_Ins&Outs_07_SE	
9	Mat_Summations_Ins&Outs_08_TX	
10	Mat_Summations_Ins&Outs_09_WD	
11	Mat_Summations_Ins&Outs_10_Total	
12	Mat_Final_Combine_Critical_Matrix_for_HGAC	Matrix combine all commodities

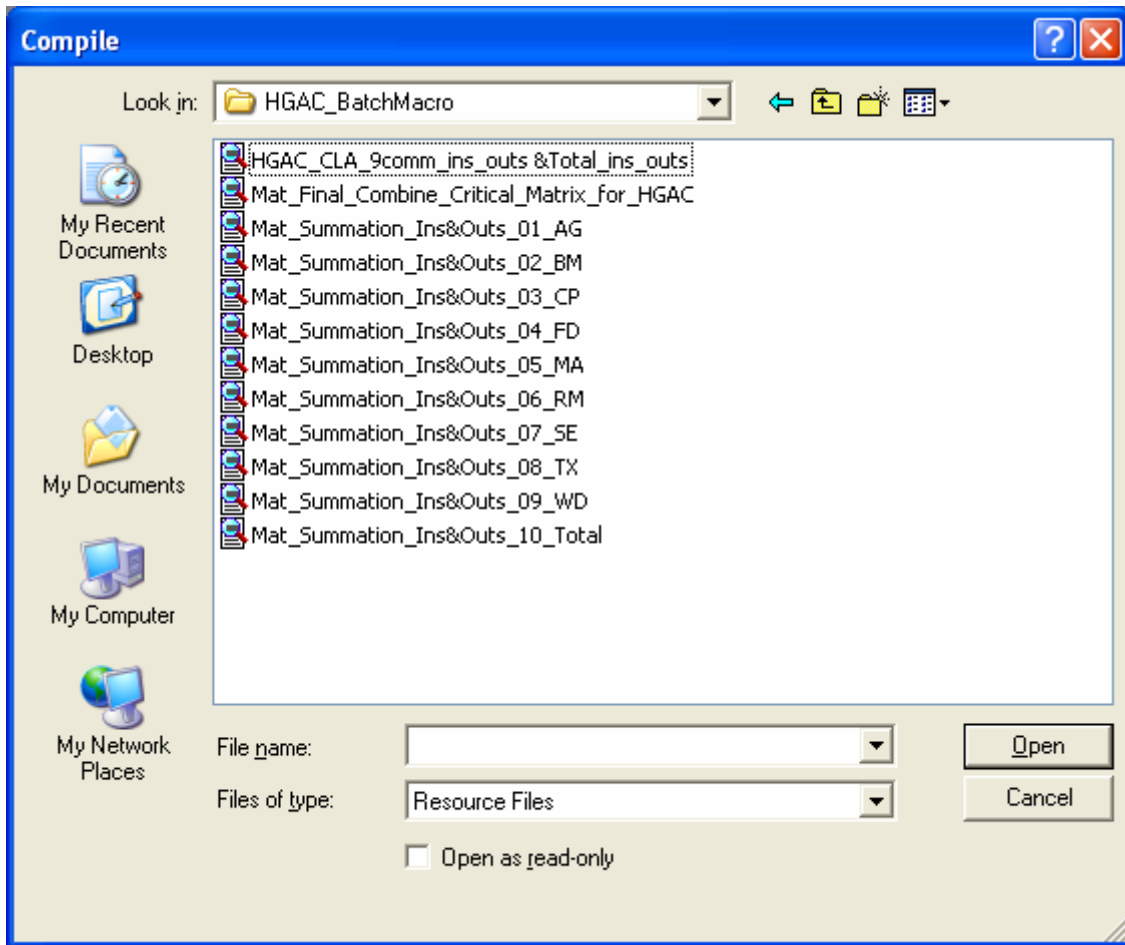


Figure 5.28. Batch Macro Resources Files.

Procedure for Running the Batch Macro in GISDK Toolbox:

- a. Choose ***Tool-Add-in***.
- b. Go to the directory (Figure 5.28) with the batch macros.
- c. Choose number 1 batch macro file.
- d. Type 'Batch Macro' in Name (Figure 5.29) and then click OK.
- e. Chose number 2 batch macro file and repeat step d.
- f. Repeat step d by opening batch macro files in sequential order from number 3 to number 12.

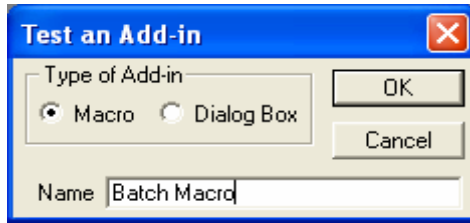


Figure 5.29. Test an Add-In.

It took about 33 minutes to run the CLA for HGA (i.e., number 1 batch macro file), but running time can vary along with speed and memory of computer used. At the end of run, the run note (Figure 5.30) and batch notepad appear on the screen (Figure 5.31).

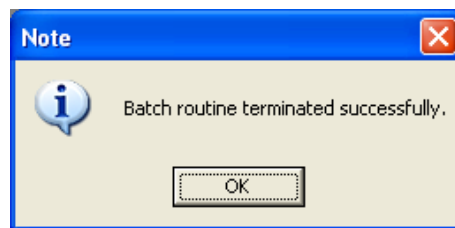


Figure 5.30. Run Message.

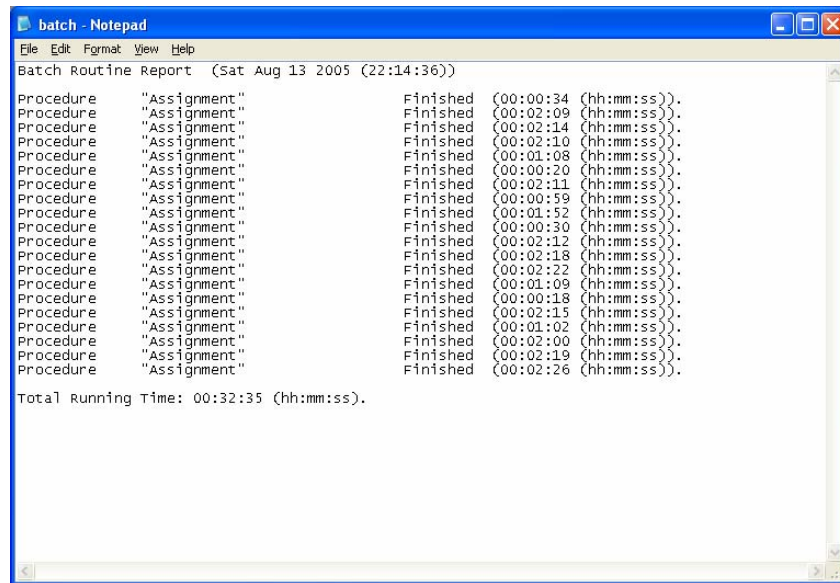


Figure 5.31. Batch Notepad Showing Total Running Time.

Table 5.33 shows the running times for the batch macro files run for HGA. Running times are measured at Celeron (R) CPU 2.4GHz.

Table 5.33. Running Times for Batch Macro Files (CLA for HGA).

SN #	File Name	Running Time (hh:mm:ss)
1	HGAC_CLA_9comm_ins_outs_Total_ins_outs	00:32:35
2	Mat_Summations_Ins&Outs_01_AG	00:00:25
3	Mat_Summations_Ins&Outs_02_BM	00:00:27
4	Mat_Summations_Ins&Outs_03_CP	00:00:25
5	Mat_Summations_Ins&Outs_04_FD	00:00:27
6	Mat_Summations_Ins&Outs_05_MA	00:00:25
7	Mat_Summations_Ins&Outs_06_RM	00:00:24
8	Mat_Summations_Ins&Outs_07_SE	00:00:22
9	Mat_Summations_Ins&Outs_08_TX	00:00:22
10	Mat_Summations_Ins&Outs_09_WD	00:00:21
11	Mat_Summations_Ins&Outs_10_Total	00:00:17
12	Mat_Final_Combine_Critical_Matrix_for_HGAC	00:02:55
Total Running Time		00:39:25

The matrices created in the CLA must be converted to another data format for analysis and use in building an external-local commodity movement table for assignment. The steps involved are as follow (see Figure 5.32):

- a. Choose **File-Open**, and go to the output directory.
- b. Open the final matrix file, e.g., ASN_CRITICAL_HGAC.mtx.

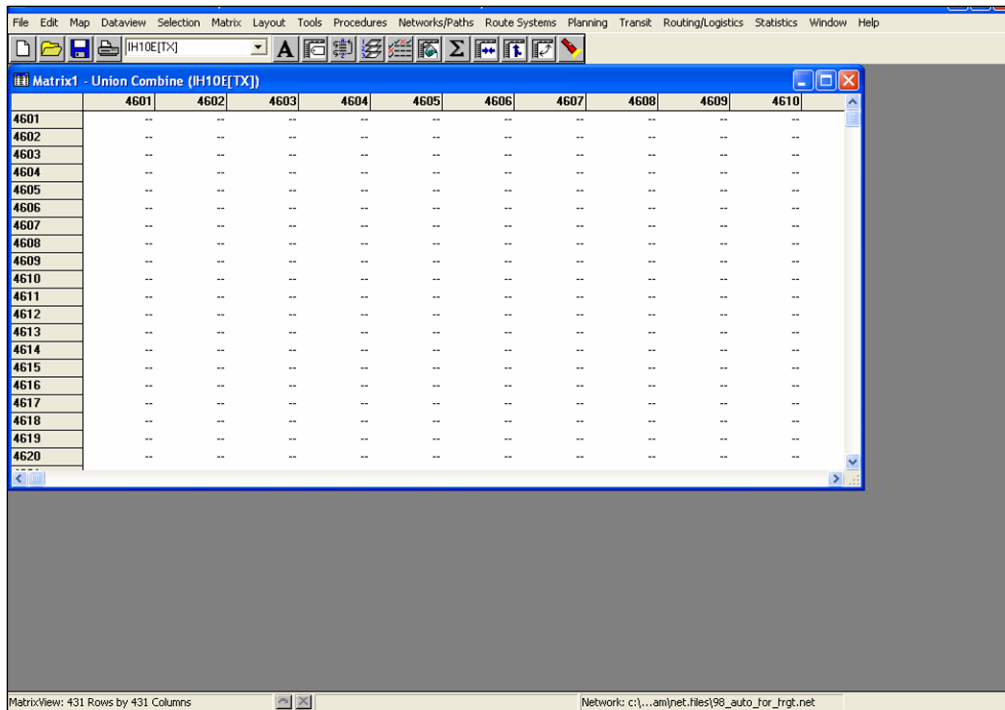


Figure 5.32. Open Matrix File.

- c. Check the number of matrices included. If the number of matrices is less than 256, choose **Matrix-Export**, and then click **Select All** to export to a table. However, since this matrix file includes 369 matrices by 41 critical links and nine commodity groups, this file is divided into two files because the dbf format has a maximum of 256 variables. Each file must contain matrices less than 256.
- d. Divide the file (with 396 matrices) into two files (each with less than 256 matrices) using **Matrix-Copy**, which easily creates two files by selecting matrices. Select matrices as shown in Figures 5.33 and 5.34. Click OK and then save it as in your directory.

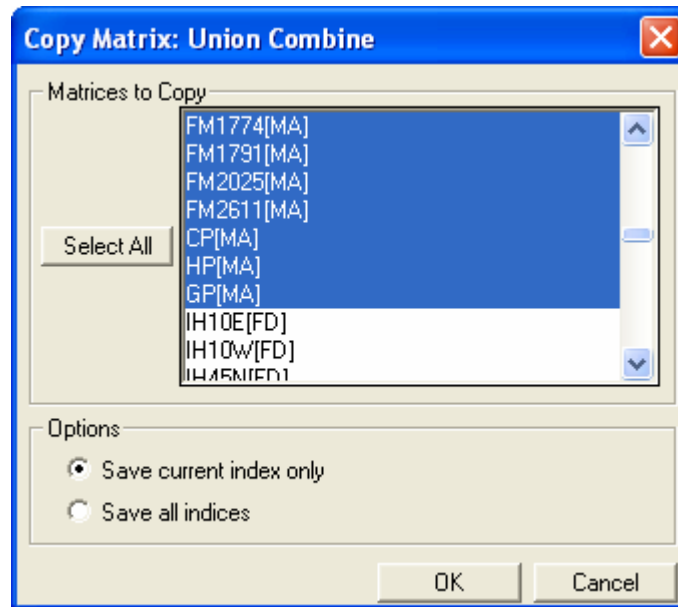


Figure 5.33. Select Matrices for the 1st File.

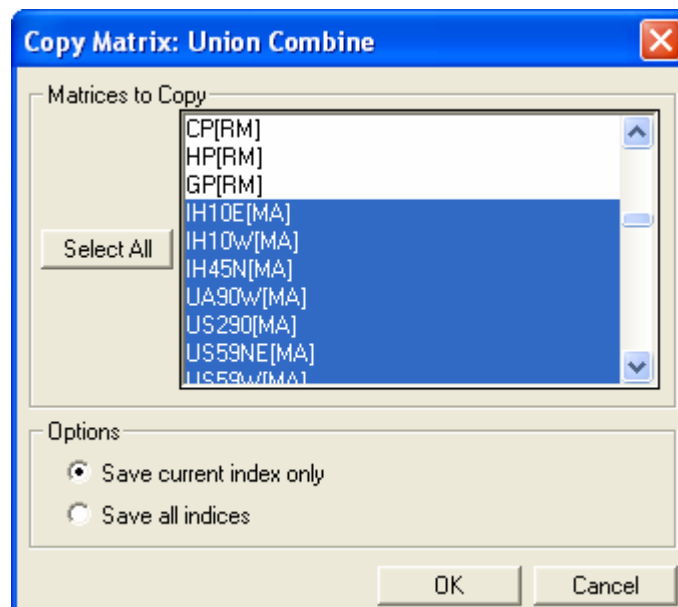


Figure 5.34. Select Matrices for the 2nd File.

- e. Open the 1st file from *File-Open*. Choose *Matrix-Export* and then click *Select All*. Save it as dBASE (.dbf) or fixed-format txt (.asc).
- f. Open the 2nd file from *File-Open*. Choose *Matrix-Export* and then click *Select All*. Save it as dBASE (.dbf) or fixed-format txt (.asc).

SAM O-D Matrices and the CLA Output

As input data, SAM O-D matrix has zonal structure at the county level. Such a structure is maintained in the CLA output called a critical link matrix resulting from critical link analysis. Thus, it is important to understand the SAM O-D matrix and its relation to urban area CLA output. This understanding is necessary for processing of output to obtain urban area flows. More importantly, when processing the CLA output (critical matrices), check the double counting in critical link matrix for “Through” flows (i.e., SAM-Ext to SAM-Ext, Non-HGA to Non-HGA, Non-HGA to SAM-Ext, and SAM-Ext to Non-HGA) and make corrections to ensure that the CLA output reflects accurate “Through” movement. The double counting occurs necessarily when critical link output is measured along any area boundary, because “through” movement is measured at both entry and exit critical links. A simple way to resolve double-counting in processing output is to divide the output of “Through” movements by 2.

Tables 5.34,5.35, and 5.36 present summaries of the CLA for HGA.

Table 5.34. SAM Input and CLA Output for HGA.

	SAM Input			CLA Output		
	HGA	Non-HGA	SAM External Station	HGA	Non-HGA	SAM External Station
HGA	SAM-II	SAM-II	SAM-IE	UA-II	UA-IE	SAM-IE
Non-HGA	SAM-II	SAM-II	SAM-IE	UA-EI	UA-EE	SAM IE
SAM Ext- Sta	SAM-EI	SAM-EI	SAM-EE	SAM EI	SAM EI	SAM EE
HGA (tons)	28,091,157	96,756,875	57,411,965	0	96,783,892	57,411,964
Non-HGA (tons)	88,635,832	205,130,165	84,021,677	88,672,082	4,649,131	7,315,768
SAM Ext- Sta (tons)	52,320,683	75,796,032	81,630,857	52,320,683	4,399,002	9,915,833
Total Truck Tons			769,795,243	Total Critical Link Truck Tons		321,468,355

The CLA data when reduced to the basic information needed for the urban model contain the tons of each commodity group that are entering and exiting the HGA urban area at each critical link. It also contains the tons of each commodity group that is entering and exiting each critical link that is traveling through the HGA. The final step will be to take this information and build commodity flow tables for each HGA external station (i.e., critical link) that may be merged with the internal flow tables.

The 1995 external station commercial vehicle survey for the HGA was used to distribute the commodity flows at each external station (76). These data were felt to be representative of the distribution of vehicles transporting commodities into, out of, and

through the HGA. The commodities were distributed to the internal zones and external stations proportionally as the observed commercial vehicle trips from the external survey. These actual trip tables for each commodity group were put into a comma delimited format in the order of external station zone number, internal/external zone number, and estimated quarter tons of commodity moving between the external station and the internal/external zone. These tables could then be imported into TransCAD for merging with the internal commodity and vehicle movement tables developed in the trip distribution step.

Table 5.35. Input Data for HGA and Link Flow Results.

	SAM Input Data										ASN_LinkFlow.bin			Through Flow at		Thorough Flow from bin file
	IE / EI		Ext-IE / EI		Total IE / EI (a)		Ext-EE	In- and Out-Flows (b)		Ins C-links (b1 - a1)	Out-Clinks (b2 - a2)					
	Prod (IE)	Attr (EI)	Prod (IE)	Attr (EI)	Prod(IE):a1	Attr (EI):a2		Out: b1	In: b2							
Agriculture	53,090	72,794	866,022	991,868	919,112	1,064,662	7,713,272	1,845,526	1,991,076	926,414	926,414	926,414	926,414	926,414		
Raw Materials	6,360,814	1,008,124	268,009	3,161	6,628,823	1,011,285	6,981,489	7,348,094	1,730,556	719,271	719,271	719,271	719,271	719,271		
Food	8,799,838	15,064,596	3,468,166	7,907,441	12,268,004	22,972,037	10,271,830	15,448,694	26,152,727	3,180,690	3,180,690	3,180,690	3,180,690	3,180,690		
Wood	4,242,215	11,804,468	1,508,281	5,779,583	5,750,496	17,584,051	9,463,801	7,992,683	19,826,237	2,242,186	2,242,186	2,242,186	2,242,186	2,242,186		
Textile	235,077	800,013	817,589	1,663,371	1,052,666	2,463,384	5,721,877	2,601,123	4,011,841	1,548,457	1,548,457	1,548,457	1,548,457	1,548,457		
Secondary	20,909,734	16,850,806	2,250,938	3,181,272	23,160,672	20,032,078	2,149,705	24,448,939	21,320,345	1,288,267	1,288,267	1,288,267	1,288,267	1,288,267		
Building Materials	11,891,622	19,183,997	5,664,651	9,807,089	17,556,273	28,991,086	13,738,592	21,230,321	32,665,135	3,674,049	3,674,049	3,674,049	3,674,049	3,674,049		
Machinery	718,912	1,829,087	2,715,457	5,666,739	3,434,369	7,495,826	14,371,444	5,964,404	10,025,861	2,530,035	2,530,035	2,530,035	2,530,035	2,530,035		
Chem_Petro	43,545,572	22,021,948	39,852,852	17,320,159	83,398,424	39,342,107	11,218,847	93,600,423	49,544,106	10,201,998	10,201,998	10,201,998	10,201,999	10,201,999		
Total annual Tons	96,756,875	88,635,832	57,411,964	52,320,683	154,168,839	140,956,515	81,630,857	180,480,206	167,267,883	26,311,367	26,311,367	26,311,367	26,311,367	26,311,367		
Total daily Tons	322,523	295,453	191,373	174,402	513,896	469,855	272,103	601,601	557,560	87,705	87,705	87,705	87,705	87,705		

Table 5.36. Critical Link Analysis for HGA (41 Critical Links).

	Non-Through Movement						Through Movement (double-counting removed)						Total Movement	% Through
	UA-IE	UA-EI	SAM-IE	SAM-EI	Total	UA-EE	SAM-IE	SAM-EI	SAM-EE	Total				
Agriculture	53,090	72,794	866,022	991,868	1,983,773	106	277,839	71,100	577,369	926,414	2,910,187	31.8		
Raw Materials	6,360,814	1,008,124	268,009	3,161	7,640,108	11,273	34,241	0	673,757	719,271	8,359,379	8.6		
Food	8,812,231	15,078,672	3,468,166	7,907,441	35,266,510	826,401	855,869	630,958	854,228	3,167,456	38,433,965	8.2		
Wood	4,245,360	11,809,311	1,508,281	5,779,583	23,342,535	719,506	198,996	549,080	770,611	2,238,192	25,580,728	8.7		
Textile	235,107	800,063	817,589	1,663,371	3,516,131	4,099	139,111	225,177	1,180,030	1,548,417	5,064,547	30.6		
Secondary	20,909,878	16,850,914	2,250,938	3,181,272	43,193,002	50,879	401,581	742,942	92,739	1,288,141	44,481,143	2.9		
Building Materials	11,901,975	19,199,589	5,664,651	9,807,089	46,573,305	530,098	447,620	541,361	2,141,997	3,661,076	50,234,380	7.3		
Machinery	718,922	1,829,093	2,715,457	5,666,739	10,930,210	2,455	523,650	340,070	1,663,853	2,530,027	13,460,237	18.8		
Chem_petro	43,546,516	22,023,522	39,852,852	17,320,159	122,743,049	2,504,315	4,436,861	1,298,314	1,961,250	10,200,740	132,943,789	7.7		
Total annual Tons	96,783,892	88,672,082	57,411,964	52,320,683	295,188,622	106	277,839	71,100	577,369	26,279,734	321,468,355	8.2		
Total daily Tons	322,613	295,574	191,373	174,402	983,962	11,273	34,241	0	673,757	87,599	1,071,561	8.2		

TRIP DISTRIBUTION

The trip distribution step in modeling essentially inputs the amount of commodity/trips that are generated and attracted to each zone. Commodity movement and vehicle movement tables are built using the ATOM2 trip distribution software used by TxDOT. This software balances the amounts being generated and attracted at each zone and constrains the distribution to a desired average trip length for each commodity group. The process discussed in the following sections was followed for the HGA and is a template for use in modeling commodities and truck movements in other urban areas.

Organization of Files

Due to the number of files necessary to perform the trip distribution and assignment processes, it is important to organize files in a manner that reduces the potential for utilizing the wrong files. The main groups of files consist of the following:

- Statewide Analysis Model Files (eight commodities);
- Urban Area Files (10 commodities);
- Urban Area Empty Vehicle File (one file, in terms of vehicle movements);
- Urban Area Non-Transfer Files (10 commodity types, in terms of vehicle movements);
- Urban Area External-Local Files (10 commodities); and
- Urban Area External-Through Files (10 commodities).

Directories to store respective files and files created in future steps are needed for each of these groups.

Preparations for Trip Distribution

Prior to performing trip distributions on the various commodities within each group, it is necessary to prepare files into the correct formats so that the distribution model will execute properly. Additionally, specific files are needed in order to run the distribution. In general, there are five necessary files, and they include:

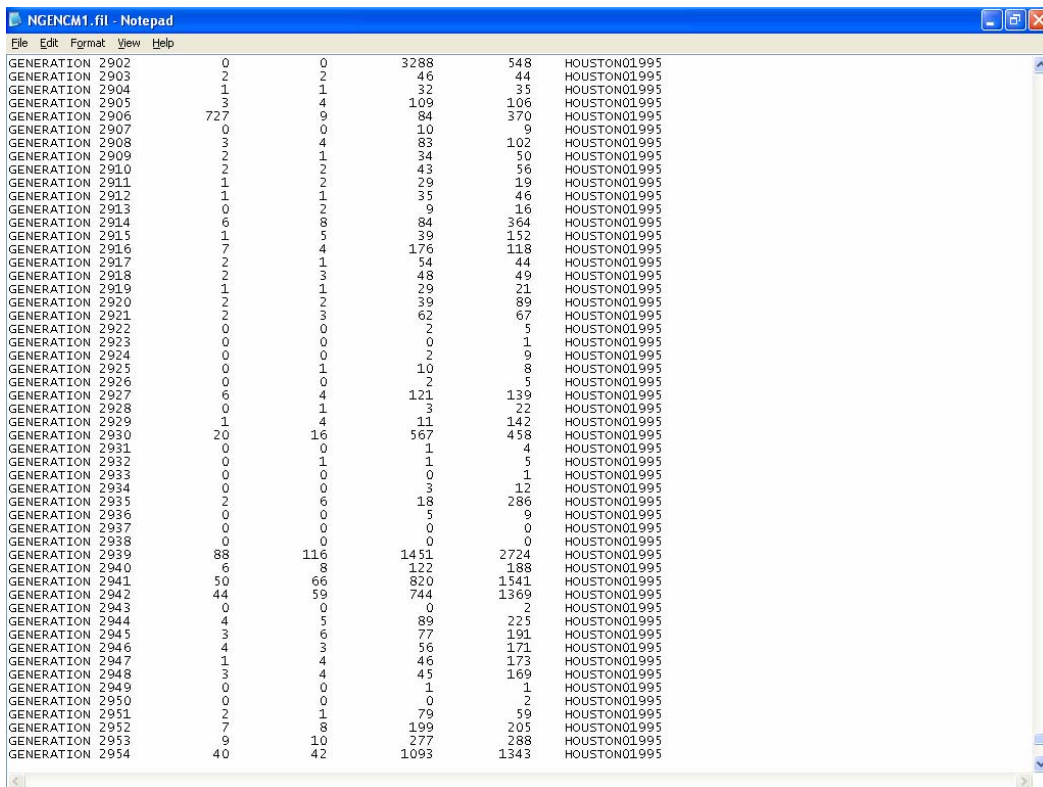
- Trip Generation File- This file is the trip generation card produced in the trip generation phase of the model. The file contains production and attraction volumes by zone.
- Control/Function File – This file contains information required for the distribution model to execute. The file provides input and output file names, data format information, and trip length frequency distribution information.
- Separation Matrix File – A matrix file in terms of either time or length that provides the separation from each zone to every other zone. This file must be in binary (.BIN) format.
- RADII File – This file contains information that measures the time from the zone centroid to the nearest point on the perimeter of the centroid area.
- Sector Table of Equals File – This file allows for the defining of a sector structure.

Some of the file types mentioned above must be created and/or modified prior to performing a trip distribution. The following will provide information on which files need to be modified and how they are to be changed.

Modifying Trip Generation Files

The trip generation files that are required for running a trip distribution typically are output in a format that does not include any data for the external zones. Figure 5.35 provides an example of what the file looks like. In this example, zone 2954 is the last internal zone. However, in order to run the trip distribution, the generation file must contain lines for the external zones. In this example, zones 2955 through 3000 are external zones. Therefore, that information must be added after the last internal zone. Figure 5.36 provides an example of a trip generation file with lines for internal and external zones.

It is important to remember that the column spacing for these files is critical and must meet the conditions specified in the control file. This process must be performed on each generation file and the modified file should be placed in the appropriate directory or sub-directory.



Zone	Internal Zone	External Zone	Zone 1	Zone 2	Zone 3
GENERATION 2902	0	0	3288	548	HOUSTON01995
GENERATION 2903	2	2	46	44	HOUSTON01995
GENERATION 2904	1	1	32	35	HOUSTON01995
GENERATION 2905	3	4	109	106	HOUSTON01995
GENERATION 2906	727	9	84	370	HOUSTON01995
GENERATION 2907	0	0	10	9	HOUSTON01995
GENERATION 2908	3	4	83	102	HOUSTON01995
GENERATION 2909	2	1	34	50	HOUSTON01995
GENERATION 2910	2	2	43	56	HOUSTON01995
GENERATION 2911	1	2	29	19	HOUSTON01995
GENERATION 2912	1	1	35	46	HOUSTON01995
GENERATION 2913	0	2	9	16	HOUSTON01995
GENERATION 2914	6	8	84	364	HOUSTON01995
GENERATION 2915	1	5	39	152	HOUSTON01995
GENERATION 2916	7	4	176	118	HOUSTON01995
GENERATION 2917	2	1	54	44	HOUSTON01995
GENERATION 2918	2	3	48	49	HOUSTON01995
GENERATION 2919	1	1	29	21	HOUSTON01995
GENERATION 2920	2	2	39	89	HOUSTON01995
GENERATION 2921	2	3	62	67	HOUSTON01995
GENERATION 2922	0	0	2	5	HOUSTON01995
GENERATION 2923	0	0	0	1	HOUSTON01995
GENERATION 2924	0	0	2	9	HOUSTON01995
GENERATION 2925	0	1	10	8	HOUSTON01995
GENERATION 2926	0	0	2	5	HOUSTON01995
GENERATION 2927	6	4	121	139	HOUSTON01995
GENERATION 2928	0	1	3	22	HOUSTON01995
GENERATION 2929	1	4	11	142	HOUSTON01995
GENERATION 2930	20	16	567	458	HOUSTON01995
GENERATION 2931	0	0	1	4	HOUSTON01995
GENERATION 2932	0	1	1	5	HOUSTON01995
GENERATION 2933	0	0	0	1	HOUSTON01995
GENERATION 2934	0	0	3	12	HOUSTON01995
GENERATION 2935	2	6	18	286	HOUSTON01995
GENERATION 2936	0	0	5	9	HOUSTON01995
GENERATION 2937	0	0	0	0	HOUSTON01995
GENERATION 2938	0	0	0	0	HOUSTON01995
GENERATION 2939	88	116	1451	2724	HOUSTON01995
GENERATION 2940	6	8	122	188	HOUSTON01995
GENERATION 2941	50	66	820	1541	HOUSTON01995
GENERATION 2942	44	59	744	1369	HOUSTON01995
GENERATION 2943	0	0	0	2	HOUSTON01995
GENERATION 2944	4	5	89	225	HOUSTON01995
GENERATION 2945	3	6	77	191	HOUSTON01995
GENERATION 2946	4	3	56	171	HOUSTON01995
GENERATION 2947	1	4	46	173	HOUSTON01995
GENERATION 2948	3	4	45	169	HOUSTON01995
GENERATION 2949	0	0	1	1	HOUSTON01995
GENERATION 2950	0	0	0	2	HOUSTON01995
GENERATION 2951	2	1	79	59	HOUSTON01995
GENERATION 2952	7	8	199	205	HOUSTON01995
GENERATION 2953	9	10	277	288	HOUSTON01995
GENERATION 2954	40	42	1093	1343	HOUSTON01995

Figure 5.35. Trip Generation Output File.

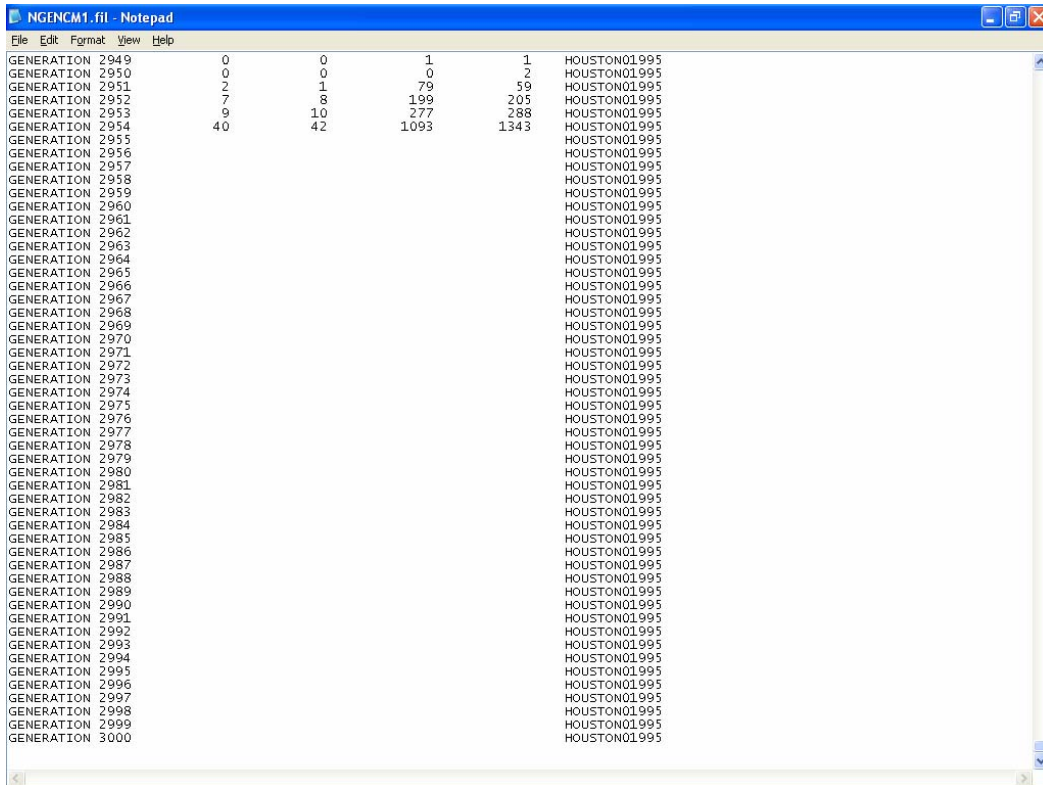


Figure 5.36. Trip Generation Output File with External Zones Added.

Modifying Separation Matrix

Another important step in the preparation of files for processing in the trip distribution phase is the proper formatting of the separation matrix. The standard output of a separation matrix that is compiled from the transportation network is in matrix format. The matrix provides the shortest time or distance (separation) between each zone and every other zone in the area. However, the trip distribution model requires that the separation values be in binary (BIN) format (rather than MTX format). A feature in TransCAD allows for the exporting of a matrix file into a binary format. Figure 5.37 shows the location of that feature. After selecting the exporting feature, the user must then specify the maximum zone value and the unit of measurement (see Figure 5.38).

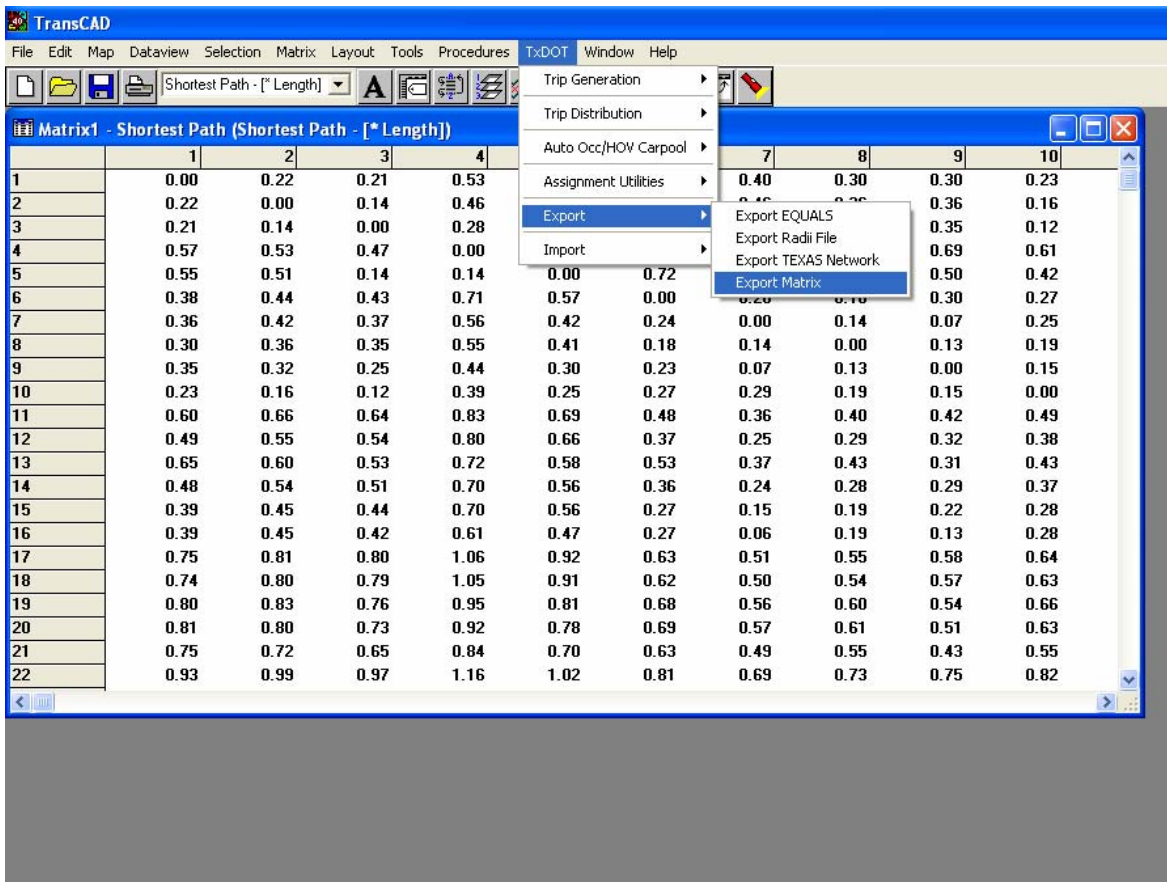


Figure 5.37. Conversion of a Matrix File to Binary Format.

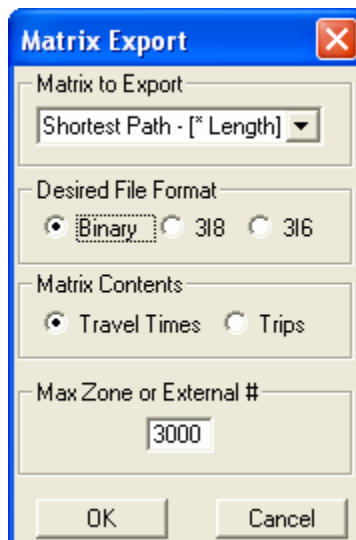


Figure 5.38. Exporting Matrix File to Binary Format.

Modifying Control File

The final trip distribution file that must be modified is the control (function) file. The process for this is more involved than the previous modifications, but it is also the most important. If the formatting for this file type is incorrect, the trip distribution model will not run properly. The control file must reference the appropriate separation matrix, radii, generation, and sector files. The file names must match exactly. Also, output file names and types must be provided. For purposes of this research, a 3I8 format was utilized for the output. This format was used due to the limited field width available for the binary output (99,999 is the maximum value). An example of the input and output files is provided below.

```
$ATOM2 MODEL
$FILE
```

```
INPUT FILE = SEPTP, USERID = $HGAC_length_SPMAT_050205.BIN$ Separation Matrix
INPUT FILE = RADII, USER ID = $RADII1995$ Radii Card
INPUT FILE = GENE, USER ID = $NGENCM1.fil$ Generation Card
INPUT FILE = EQUATE, USER ID = $SECTOE47.TXT$ Sector Card
OUTPUT FILE = TRIP-3I8, USER ID = $HGACAG.3I8$ 3I8 Output
OUTPUT FILE = LISTING, USER ID = $HGACAG.OUT$ Summary Output
```

Next, the header, values, and format lines need to be modified. The header line is one that will be inserted in the .OUT file that is produced when running trip distributions. Due to the number of files that are required and produced during the trip distribution, it is important to modify the header information to include the appropriate commodity and the date that the distribution was performed.

```
$HEADERS
```

```
HGAC 1995 Agriculture
COMMODITY DISTRIBUTION WITH ESTIMATED TLF (RUN 06/01/05)
```

The next values that needed to be checked are in the “parameters.” The first line in this section contains the maximum internal zone number. The next line identifies the maximum external zone number.

```
$PARAMETERS
```

```
&VALUES M= 2954 &END (Maximum Internal Zone Number)
&VALUES N= 3000 &END (Maximum External Zone Number)
```

The first FORMAT line specifies the location of the zonal production and attraction information in the generation card. It is critical that the formatting information in this line matches the structure of the generation file. In the example below, the productions are found starting at column 16 and have a field width of value of 12. The attractions start at column 28 and also have a field width of a value of 12. The second FORMAT line pertains to the trip length frequency distribution (TLFD) information and it does not need to be modified. After the FORMAT lines, data pertaining to the TLFD is inserted.

FORMAT(A4,T11,I5,T16,F12.0,T28,F12.0)	Agriculture	GENERATION
FORMAT(A4,T12,I5,F15.0,T65,A4)		LENGTH
LENGTH 1 6.7102 1508.58		AGR1995
LENGTH 2 9.1837 2064.68		AGR1995

The next step that needs to be performed is modifying the TLFD to represent the commodity that will be distributed. TransCAD has a feature that allows for the calculation of a TLFD (select “TxDOT / Trip Distribution / ITLFDM TransCAD”). In order to produce a TLFD for a particular commodity, the user needs to know the average and maximum trip length for the commodity and the total number of trips for the commodity. The trip purpose must also be specified. The trip purposes do not all have the same distribution curve, so it is important to use the same trip purpose for all of the commodities. For the purpose of the freight model, the truck-taxi (TRTX) trip purpose was utilized. Figure 5.39 provides an example of the TLFD macro.

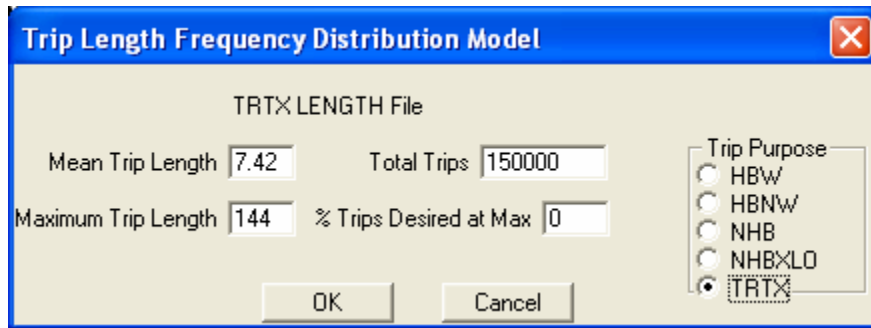


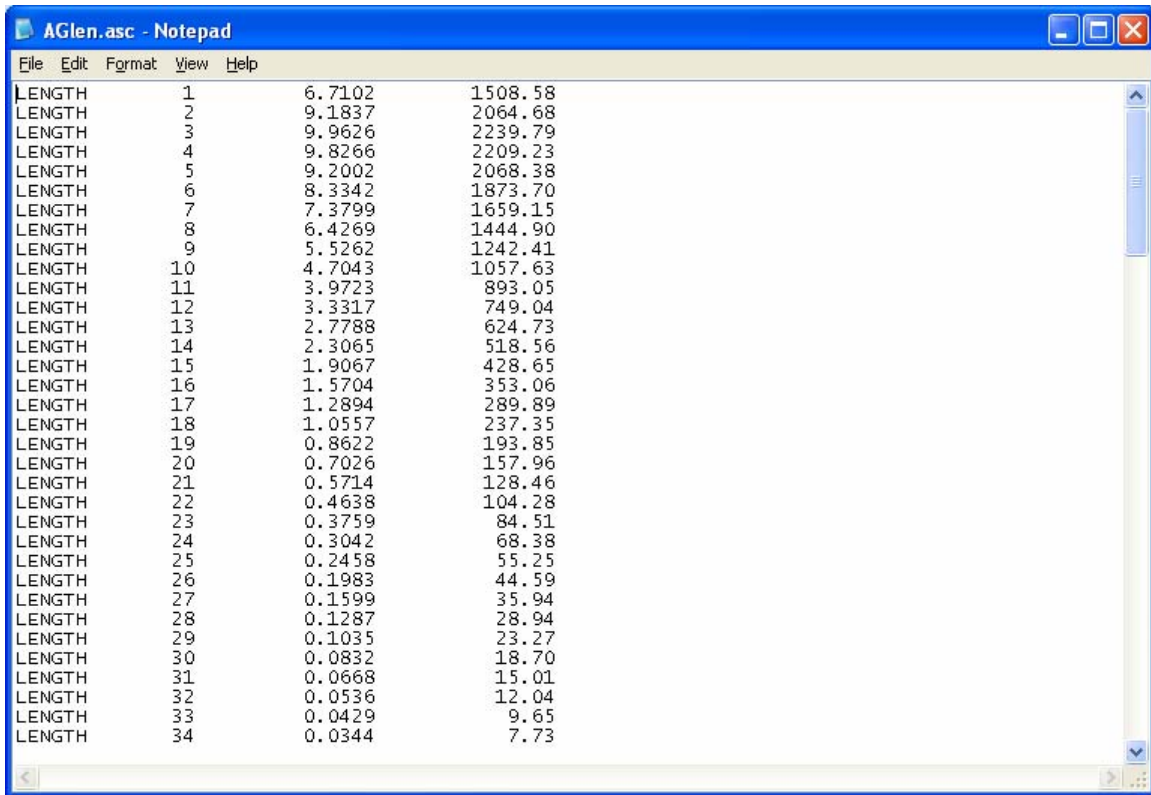
Figure 5.39. Trip Length Frequency Distribution Macro.

Table 5.37 shows the average trip lengths from the commercial vehicle data analysis. The average trip length for empty vehicle trips was 12.63 miles and 18.83 minutes.

Table 5.37. Average Trip Lengths.

Commodity Group	Commodity Average Trip Length		Non-Transfer Trip Average Trip Length	
	Miles	Minutes	Miles	Minutes
Agriculture	7.42	11.14	13.76	20.51
Raw Materials	5.12	8.09	9.27	14.37
Food	7.54	11.32	20.31	29.13
Textiles	6.78	10.23	10.90	16.47
Wood	11.75	17.26	13.70	20.76
Building Materials	14.42	20.61	29.68	37.64
Machinery	12.33	18.34	14.25	20.94
Miscellaneous	12.46	18.14	15.24	21.84
Secondary	7.13	12.05	7.99	13.65
Hazardous Materials	12.06	17.31	11.15	17.03
All Combined	9.32	13.85	15.31	21.83

After entering the required information and clicking on OK, the user is prompted to enter an output file name. When the user specifies and enters an output file name, the macro will execute and produce a file similar to the one shown in Figure 5.40.



The screenshot shows a Notepad window with the title 'AGlen.asc - Notepad'. The window contains a table with three columns: 'LENGTH', a numerical index, and two numerical values. The data is as follows:

LENGTH	Index	Value 1	Value 2
LENGTH	1	6.7102	1508.58
LENGTH	2	9.1837	2064.68
LENGTH	3	9.9626	2239.79
LENGTH	4	9.8266	2209.23
LENGTH	5	9.2002	2068.38
LENGTH	6	8.3342	1873.70
LENGTH	7	7.3799	1659.15
LENGTH	8	6.4269	1444.90
LENGTH	9	5.5262	1242.41
LENGTH	10	4.7043	1057.63
LENGTH	11	3.9723	893.05
LENGTH	12	3.3317	749.04
LENGTH	13	2.7788	624.73
LENGTH	14	2.3065	518.56
LENGTH	15	1.9067	428.65
LENGTH	16	1.5704	353.06
LENGTH	17	1.2894	289.89
LENGTH	18	1.0557	237.35
LENGTH	19	0.8622	193.85
LENGTH	20	0.7026	157.96
LENGTH	21	0.5714	128.46
LENGTH	22	0.4638	104.28
LENGTH	23	0.3759	84.51
LENGTH	24	0.3042	68.38
LENGTH	25	0.2458	55.25
LENGTH	26	0.1983	44.59
LENGTH	27	0.1599	35.94
LENGTH	28	0.1287	28.94
LENGTH	29	0.1035	23.27
LENGTH	30	0.0832	18.70
LENGTH	31	0.0668	15.01
LENGTH	32	0.0536	12.04
LENGTH	33	0.0429	9.65
LENGTH	34	0.0344	7.73

Figure 5.40. Example Trip Length Frequency Distribution Output.

The output from the TLFD macro is then inserted into the control file. As with the other portions of the control file, it is important that the structure of the TLFD information is consistent with the specified format. A text editing program was used to copy the TLFD output information and to insert it in the corresponding control file. As with other phases in the process, it is extremely important that the correct TLFD for a particular commodity is input into the correct control file. For this reason, TLFD sub-folders were created for each of the groups so that the TLFD output files could be stored in them. An example of a commodity control file with a modified TLFD is provided in Figure 5.41. The TLFD process was performed on each commodity in each of the groups (SAM, Urban Area Commodities, External-Local, etc.).

```

HGAC95AG - Notepad
File Edit Format View Help
$ATOM2 MODEL
$FILE
  INPUT FILE = SEPTP, USERID = $HGAC_length_SPMAT_050205.BIN$
  INPUT FILE = RADII, USER ID = $RADII1995$
  INPUT FILE = GENE, USER ID = $NGENCM1.F11$
  INPUT FILE = EQUATE, USER ID = $SECTOE47.TXT$
  OUTPUT FILE = TRIP-318, USER ID = $HGACAG.318$
  OUTPUT FILE = LISTING, USER ID = $HGACAG.OUT$
$HEADERS
  HGAC 1995 Agriculture
  COMMODITY DISTRIBUTION WITH ESTIMATED TLF (RUN 06/01/05)
$PARAMETERS
  &VALUES M= 2954 &END
  &VALUES N= 3000 &END
  &VALUES TABLE= 1 &END
  &VALUES LIMIT= 5 &END
  REPORT = L1(1),X1(1-5),S1(1-5),A1(5),Z1,R1,A2(5),A3(5),L1(5),GET2
$DATA
FORMAT(A4,T11,I5,T16,F12.0,T28,F12.0)
FORMAT(A4,T12,I5,F15.0,T65,A4)
  LENGTH      1      6.7102      1508.58      AGR1995
  LENGTH      2      9.1837      2064.68      AGR1995
  LENGTH      3      9.9626      2239.79      AGR1995
  LENGTH      4      9.8266      2209.23      AGR1995
  LENGTH      5      9.2002      2068.38      AGR1995
  LENGTH      6      8.3342      1873.70      AGR1995
  LENGTH      7      7.3799      1659.15      AGR1995
  LENGTH      8      6.4269      1444.90      AGR1995
  LENGTH      9      5.5262      1242.41      AGR1995
  LENGTH     10      4.7043      1057.63      AGR1995
  LENGTH     11      3.9723      893.05      AGR1995
  LENGTH     12      3.3317      749.04      AGR1995
  LENGTH     13      2.7788      624.73      AGR1995
  LENGTH     14      2.3065      518.56      AGR1995
  LENGTH     15      1.9067      428.65      AGR1995
  LENGTH     16      1.5704      353.06      AGR1995
  LENGTH     17      1.2894      289.89      AGR1995
  LENGTH     18      1.0557      237.35      AGR1995
  LENGTH     19      0.8622      193.85      AGR1995
  LENGTH     20      0.7026      157.96      AGR1995
  LENGTH     21      0.5714      128.46      AGR1995
  LENGTH     22      0.4638      104.28      AGR1995
  LENGTH     23      0.3759      84.51      AGR1995
  LENGTH     24      0.3042      68.38      AGR1995
  LENGTH     25      0.2458      55.25      AGR1995
  LENGTH     26      0.1983      44.59      AGR1995
  LENGTH     27      0.1599      35.94      AGR1995
  LENGTH     28      0.1287      28.94      AGR1995
  LENGTH     29      0.1035      23.27      AGR1995
  LENGTH     30      0.0832      18.70      AGR1995
  LENGTH     31      0.0668      15.01      AGR1995
  LENGTH     32      0.0596      12.04      AGR1995
  LENGTH     33      0.0429      9.65      AGR1995

```

Figure 5.41. Example Control File.

After updating all of the control files, several files should be copied into each directory in which the trip distribution will be performed. The ATOM2 executable file, the Radii file, the separation matrix, and the sector file should be copied into each directory in which the distribution will be run. Figure 5.42 provides an example directory and the files that are contained within it. The directory contains two sub-directories; one for the TLFDD output files and one for the trip distribution output files that will be produced after running Atom2. Following the two sub-directories are the Atom2 executable file, the 10 commodity control files, the separation matrix file, 5 generation files, the radii file, and the sector file.

File Name	Size	Type
Internal TLFDD		File Folder
OUT 3I8		File Folder
atom2	472 KB	Application
HGAC95AG	15 KB	CTL File
HGAC95BM	18 KB	CTL File
HGAC95FD	13 KB	CTL File
HGAC95HM	15 KB	CTL File
HGAC95MC	14 KB	CTL File
HGAC95MI	14 KB	CTL File
HGAC95RM	14 KB	CTL File
HGAC95SD	14 KB	CTL File
HGAC95TX	14 KB	CTL File
HGAC95WD	14 KB	CTL File
HGAC_length_SPMAT_050205	17,501 KB	BIN File
NGENCM1.fil	241 KB	FIL File
NGENCM2.fil	241 KB	FIL File
NGENCM3.fil	241 KB	FIL File
NGENCM4.fil	241 KB	FIL File
NGENCM5.fil	241 KB	FIL File
radii1995	81 KB	File
sectoe47	50 KB	Text Document

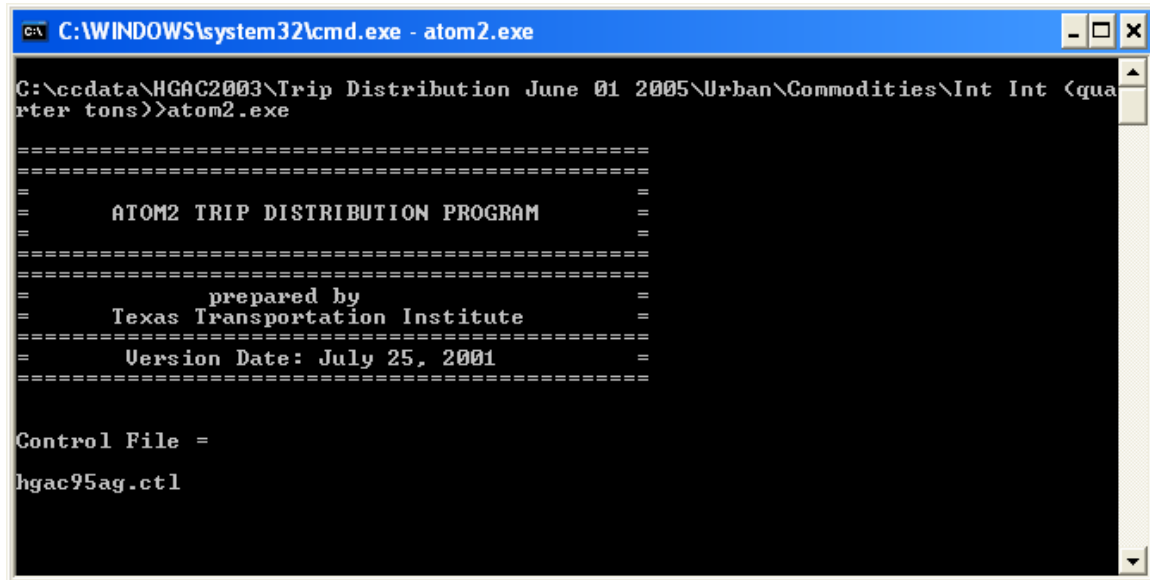
Figure 5.42. Example Directory Composition.

Trip Distribution Execution

The trip distribution process was conducted by running the ATOM2 program. When running ATOM2, the program will produce two output files. One file is in 3I8 format and it contains the data that will be imported into a production/attraction (P-A) matrix. The other file (*.OUT) contains summary data and statistics that can be used to check various aspects of the distribution. A key piece of information is located in Table L1(5) of the .OUT file. After a trip distribution run is made, Table L1(5) must be checked to see if the resulting average internal trip length matches the desired average internal trip length for the commodity being processed. Typically, this does not happen on the first run of data through ATOM2. As a result, the following sections will describe how to run ATOM2, how to check the resulting average trip length, and how to modify the control file to obtain a desired and resulting average trip length that are within reasonable limits.

Running ATOM2

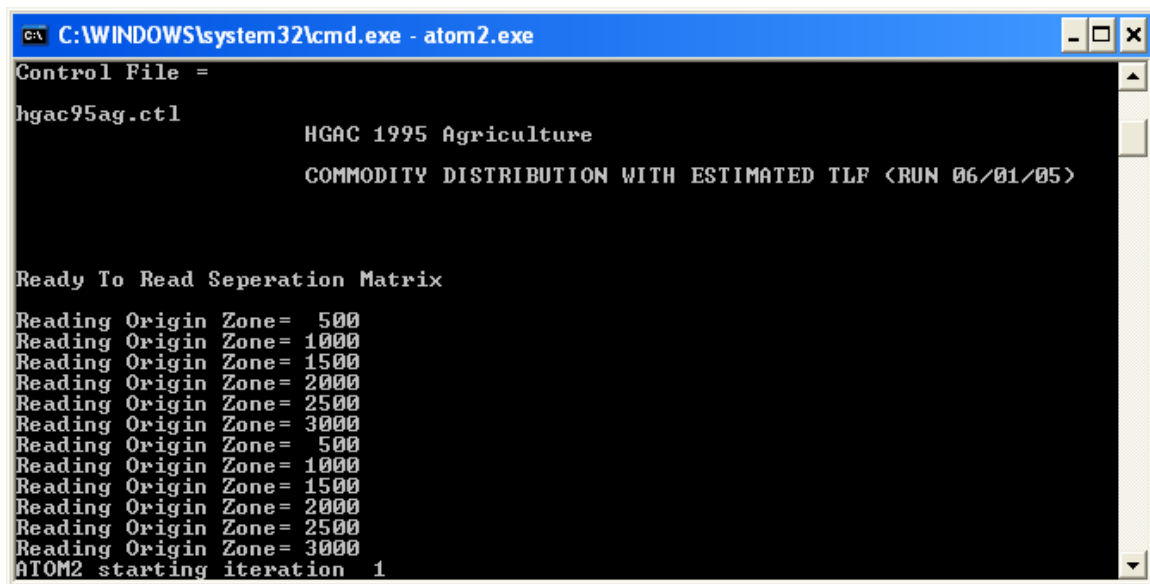
Running the ATOM2 application may be performed in the Windows or DOS environment. It is recommended that it is run in DOS. To do this, open the DOS command prompt from the Windows environment. Next, the path to the appropriate directory must be specified. Once in the proper directory, the user should type in “atom2.exe” and press the “enter” key. After doing this, the screen will look like Figure 5.43.



```
C:\WINDOWS\system32\cmd.exe - atom2.exe
C:\ccdata\HGAC2003\Trip Distribution June 01 2005\Urban\Commodities\Int Int (quarter tons)>atom2.exe
=====
=
=          ATOM2 TRIP DISTRIBUTION PROGRAM          =
=
=====
=
=          prepared by                               =
=          Texas Transportation Institute             =
=          Version Date: July 25, 2001              =
=
=====
Control File =
hgac95ag.ct1
```

Figure 5.43. Command Prompt for Running ATOM2.

Next, enter the control file that is to be processed through the program and press the “enter” key. An example control file name is provided in Figure 5.43. The ATOM2 program will execute and begin processing the supplied data. Figure 5.44 provides an example of what the program looks like while running.



```
C:\WINDOWS\system32\cmd.exe - atom2.exe
Control File =
hgac95ag.ct1
HGAC 1995 Agriculture
COMMODITY DISTRIBUTION WITH ESTIMATED TLF <RUN 06/01/05>

Ready To Read Seperation Matrix
Reading Origin Zone= 500
Reading Origin Zone= 1000
Reading Origin Zone= 1500
Reading Origin Zone= 2000
Reading Origin Zone= 2500
Reading Origin Zone= 3000
Reading Origin Zone= 500
Reading Origin Zone= 1000
Reading Origin Zone= 1500
Reading Origin Zone= 2000
Reading Origin Zone= 2500
Reading Origin Zone= 3000
ATOM2 starting iteration 1
```

Figure 5.44. ATOM2 during the Processing of Data.

As mentioned before, ATOM2 will produce two output files. The 3I8 file is the trip distribution information needed to continue in the process, and the .OUT file contains summary statistics. An example of the 3I8 output is provided in Figure 5.45.

Column 1	Column 2	Column 3
1	109	1
1	322	1
1	692	1
1	823	1
1	1112	1
1	1170	1
1	1274	1
1	1518	1
1	1603	1
4	62	1
4	268	1
4	322	1
4	514	1
4	691	1
4	748	1
4	818	1
4	982	1
4	1112	1
4	1143	1
4	1171	1
4	1233	1
4	1275	1
4	1483	1
4	1525	1
4	1553	1
4	2125	1
5	127	1
5	322	1
5	682	1
5	773	1
5	1092	1
5	1139	1
5	1214	1
5	1364	1

Figure 5.45. ATOM2 3I8 Output File.

Checking the Resulting Average Internal Trip Length

The .OUT file is a critical piece in the trip distribution process. As previously mentioned, after running ATOM2, it is necessary to review Table L1(5) of the OUT file to determine if the desired and resulting average internal trip lengths are reasonably close to one another. This information is provided at the bottom of this Table. Typically, any difference of less than 1-2 percent is acceptable, but for the purpose of the freight model it was attempted to get the difference to less than 0.1 percent. Figure 5.46 provides an example of this table. In the figure, it shows that the desired average internal trip length is 7.41844 and the average internal trip length resulting from the trip distribution is 7.42732. This results in a percent difference of 0.11971. The next line provides the desired and resulting number of internal movements that resulted from the trip distribution.

The example provided shows a trip distribution that has a resulting average internal trip length that is acceptable for moving forward in the process of running a traffic assignment. However, in many instances, the desired and resulting average internal trip lengths will not be so close. The

next section will discuss how to modify the control file in order to get these variables to match more closely.

```

1          HGAC 1995 Agriculture
          COMMODITY DISTRIBUTION WITH ESTIMATED TLF (RUN 06/01/05)

OTABLE L1( 5)          TRIP LENGTH BALANCE (ITERATION 5)
0
SEPARATION  PERCENT  PERCENT  DESIRED  RESULTING  DIFFERENCE  PCT ERR  CHI-SQUARE  RELAF
          151  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          152  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          153  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          154  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          155  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          156  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          157  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          158  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          159  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          160  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          161  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          162  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          163  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          164  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          165  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          166  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          167  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          168  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          169  0.0000  0.0000  0.0      0.0      0.0      0.000  0.0      -1.
          -----
                                114.6
0
0          AVERAGE INTERNAL TRIP LENGTH      DESIRED      RESULTING      PERCENT DIFFERENCE
          TOTAL INTERNAL TRAVEL              166781.      166981.      0.11971
1          HGAC 1995 Agriculture
          COMMODITY DISTRIBUTION WITH ESTIMATED TLF (RUN 06/01/05)

OTABLE A3( 5)  TOTAL INTRAZONAL TRIPS =      1794.0
  
```

Figure 5.46. Table L1(5) in the ATOM2 .OUT File.

Modifying the Control File F-Function Variable

After initially performing a trip distribution on a particular commodity and checking Table L1(5) of the OUT file for the resulting average internal trip length, it may be necessary to modify the control file in order to get the resulting trip length closer to the desired trip length. In order to influence the average internal trip length that will result from running ATOM2, an F-Function variable is needed in the control file. An example F-Function line is provided in Figure 5.47. The function is applied after the length information and prior to the END statement (second to last line in the control file). As with other setup files, it is important that the column formatting of this line is in the proper alignment.

The structure of the F-Function line includes the name (F-Function), the maximum distance separation (144), the function type (4, represents negative exponential), and the variable that will need to be adjusted (0.2587). If the variable is adjusted up, then generally the resulting average internal trip length will be reduced. If the variable is lowered, then the resulting trip length will typically increase.

To modify the variable, the control file should be opened with a text editor program. At this point, the variable may be changed (making sure to preserve the column formatting), then the file may be saved then closed.

```

HGAC95AG - Notepad
File Edit Format View Help
LENGTH      114      0.0000      0.00      AGR1995
LENGTH      115      0.0000      0.00      AGR1995
LENGTH      116      0.0000      0.00      AGR1995
LENGTH      117      0.0000      0.00      AGR1995
LENGTH      118      0.0000      0.00      AGR1995
LENGTH      119      0.0000      0.00      AGR1995
LENGTH      120      0.0000      0.00      AGR1995
LENGTH      121      0.0000      0.00      AGR1995
LENGTH      122      0.0000      0.00      AGR1995
LENGTH      123      0.0000      0.00      AGR1995
LENGTH      124      0.0000      0.00      AGR1995
LENGTH      125      0.0000      0.00      AGR1995
LENGTH      126      0.0000      0.00      AGR1995
LENGTH      127      0.0000      0.00      AGR1995
LENGTH      128      0.0000      0.00      AGR1995
LENGTH      129      0.0000      0.00      AGR1995
LENGTH      130      0.0000      0.00      AGR1995
LENGTH      131      0.0000      0.00      AGR1995
LENGTH      132      0.0000      0.00      AGR1995
LENGTH      133      0.0000      0.00      AGR1995
LENGTH      134      0.0000      0.00      AGR1995
LENGTH      135      0.0000      0.00      AGR1995
LENGTH      136      0.0000      0.00      AGR1995
LENGTH      137      0.0000      0.00      AGR1995
LENGTH      138      0.0000      0.00      AGR1995
LENGTH      139      0.0000      0.00      AGR1995
LENGTH      140      0.0000      0.00      AGR1995
LENGTH      141      0.0000      0.00      AGR1995
LENGTH      142      0.0000      0.00      AGR1995
LENGTH      143      0.0000      0.00      AGR1995
LENGTH      144      0.0000      0.00      AGR1995
F-FUNCTION  144      4      0.2587      100.0      HGAC Agriculture 1995 F-FACTORS 06/01/2005
END
  
```

Figure 5.47. F-Function Variable in Control File.

After modifying the F-Function variable, ATOM2 should be run again using the process described above. After running ATOM2, the OUT file should be checked again to determine what impact the change to the F-Function variable had on the resulting average internal trip length. It is advisable to keep notes on the variable value used and the trip length that results from it. It is highly likely that it will be necessary to run ATOM2 multiple times before there is an acceptable convergence of the desired and resulting average internal trip lengths for a particular commodity.

It was previously mentioned in the “Running ATOM2” section that executing ATOM2 in the DOS environment was recommended. The program will run in either environment, but there is a shortcut that allows for quicker processing of data when operating in DOS. Since it is likely that ATOM2 will be run multiple times for each commodity, this shortcut can be useful. After running ATOM2 one time, the user can hit the “up” arrow on the keyboard. Doing this will automatically insert the text “atom2.exe” in the command line. After pressing “enter,” hit the “up” arrow again and DOS will insert the control file name last used. Pressing “enter” a second time will begin the processing of that data-set through ATOM2.

As with other sections of the process, the trip distribution process should be performed on all of the data-sets in each of the groups (SAM, Urban Internal, External-Local, etc.). Care should be taken to ensure that output files from the distribution are kept separated by groups.

Creating Matrix Files

At this point, data are ready to be imported into matrices so that they may be prepared for running a traffic assignment. The process of building, combining, and factoring matrices is complex and can be memory intensive (in terms of computer processing). Extreme care should be taken to ensure that the appropriate inputs are used for each matrix. It is advisable to create supplemental tables in a spreadsheet format that contain control totals for each commodity and group. After a matrix is built, then the control total values from the spreadsheet can be compared to the totals provided in the matrix marginals in TransCAD.

With regard to the freight model, four of the six groups were processed through ATOM2 to obtain trip distribution estimates for each of the commodities within those groups. However, external-local and external-through commodity groups were not processed in that fashion. The following section will discuss how to input external-local and external-through data into matrix format as well as converting the data from weight to vehicles.

Importing External Data-Sets

The data for external-local and external-through movements are provided in a comma-delimited format (see Figure 5.48). In order to import these data into a matrix file, it is necessary to first perform a few steps. The steps are described below.

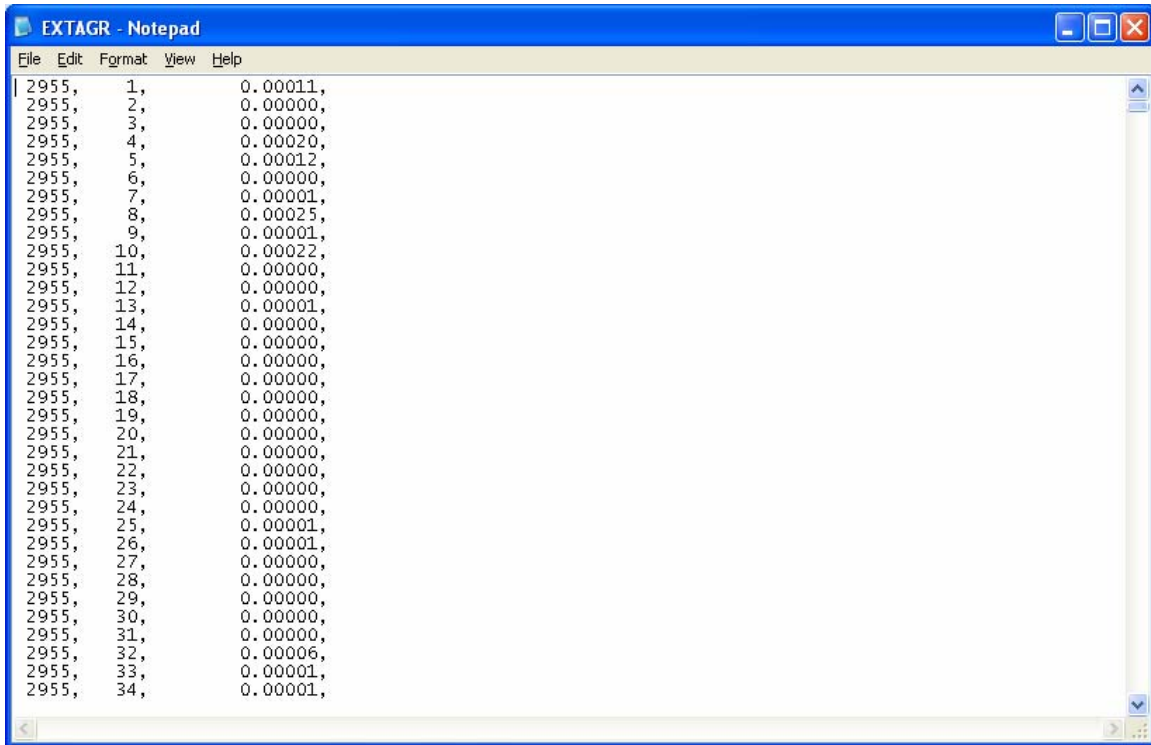


Figure 5.48. External-Local Raw Data.

1. Open the TXT file in TransCAD.
2. Save the TXT file as an ASC file.
3. Close the dataview that is open.
4. Open the ASC file that was created. There should be four columns, with the last one being empty.
5. Select *Dataview / Modify Table*. Figure 5.49 shows the resulting screen.
6. Click on *FIELD_1*. In the *Field Storage Information* area, replace the name with *DEST*.
7. Click on *FIELD_2*. Replace the name with *ORIG*.
8. Click on *FIELD_3*. Replace the name with the name of the commodity.
9. Click on *FIELD_4*. (the line should now be highlighted) and then select *Drop Field*. This will remove that field.
10. After these changes are made, select *OK*. The program will prompt the user if they want to modify the structure of the table. Select *Yes*.
11. After selecting *Yes*, the table will be revised and be ready for importation into matrix format.

Modify Table [Close]

Field Name	Type	Width	Decimals	Index
FIELD_1	Integer	11		
FIELD_2	Integer	11		
FIELD_3	Real Number	15	4	
FIELD_4	Character	10		

Field Storage Information

Name: Index

Type: Width: Decimals:

Default:

Field Display Settings

Width: Format: Decimals:

Display Name:

Description:

Record Information

Add Records

Buttons: OK, Cancel, Add Field, Drop Field, Move Up, Move Down, Attach Codes, Drop Codes, Export Codes, Aggregation

Figure 5.49. Modifying the Dataview.

With the ASC file modified, the data are ready to be imported into a matrix file. Select **Matrix/Import** from the pull-down menu. The user will be prompted by the following menu shown in Figure 5.50.

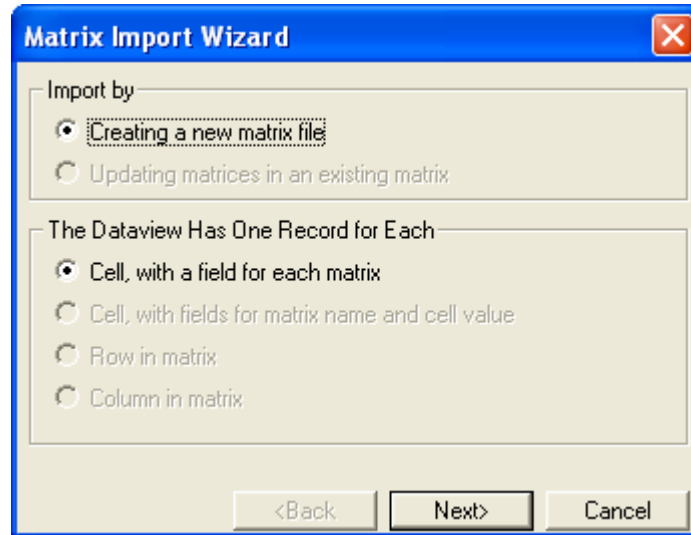


Figure 5.50. Importing a Matrix, Step 1.

Select **Next**, and the program will request that the user specify the location of origin and destination information. Figure 5.51 illustrates how the fields should be filled in. The user should fill in the **Row ID** and **Column ID** fields from the pull-down boxes. After doing this, select **Next**.

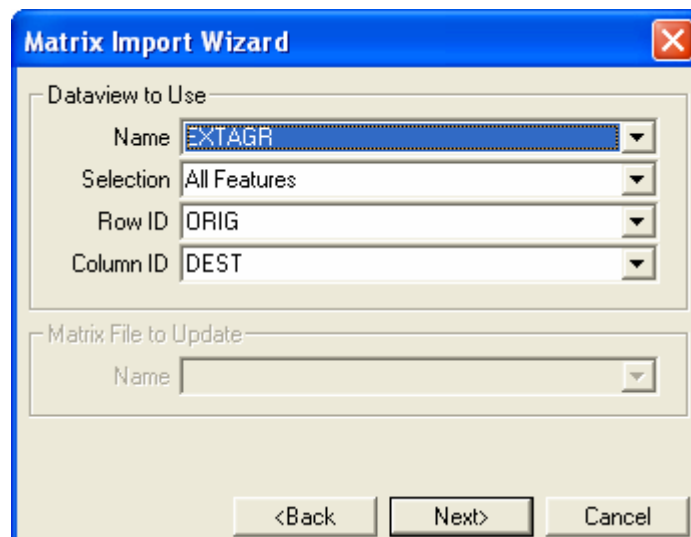


Figure 5.51. Importing a Matrix, Step 2.

The program will then ask the user to specify the field in which the movement information is located (see Figure 5.52). This field will be the name of the commodity specified in Step 8 of the converting TXT to ASC process described above. Select this field (typically it is the third field listed) and select *Finish*.

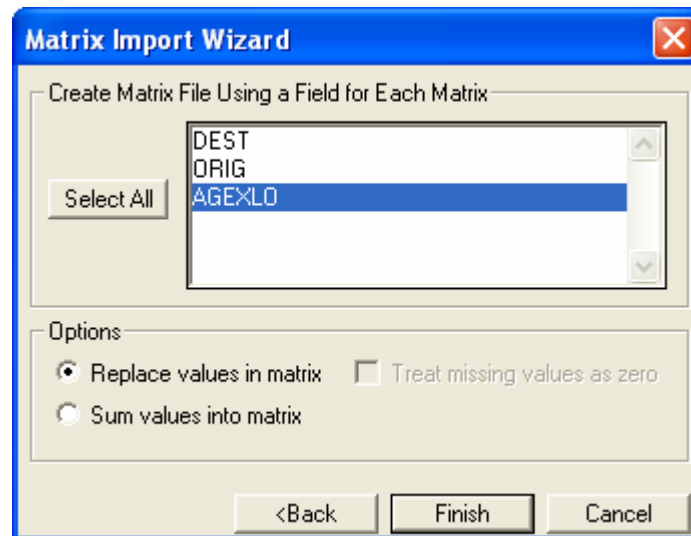


Figure 5.52. Importing a Matrix, Step 3.

After selecting *Finish*, the user will be prompted to supply a file name to save the file as. It is recommended to use a file name that is descriptive (such as AG EXLO for agriculture external-local). The resulting matrix will resemble the one provided in Figure 5.53.

	2955	2956	2957	2958	2959	2960	2961	2962	2963	2964	2965	2966	Sum
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.36
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.25
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.25
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.29
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.30
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1	0.00
Sum	0.21	0.00	0.11	5.23	0.02	0.02	0.00	151.93	0.00	0.00	0.00	0.1	419.82

Figure 5.53. Example External-Local Matrix.

As shown in Figure 5.53, TransCAD will compute the marginals (totals) for the columns, rows, and the entire matrix. The total value (419.82 in the example) can be checked against the control total for each commodity to ensure that the data imported correctly. This same process should be used to import all of the external-local and external-through data for each of the commodity types.

At this point in the freight model process, there were 10 external-local and 10 external-through matrices (one matrix for each of the 10 commodities). Each matrix contained zonal movements in terms of tons of a commodity. Before combining any matrices, the external-local and external-through commodity matrices first have to be converted to vehicles. In order to accomplish that, a second matrix was created within the MTX file. In order to do this, select *Matrix/Contents*. When this is done, a box like the one shown in Figure 5.54 will appear. Then select *Add Matrix*. Click on *Matrix 2* and the *Rename* button will activate (see Figure 5.55). Select *Rename* and enter the desired name for the matrix layer in the box that appears (Figure 5.56) and then select *OK*. As with other phases of the process, it is a good idea to be descriptive with the layer name.

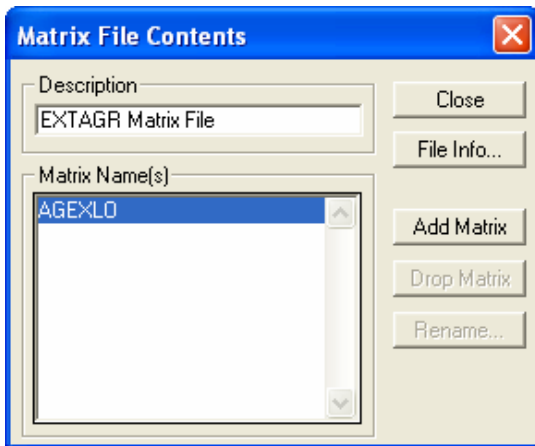


Figure 5.54. Adding a Matrix.

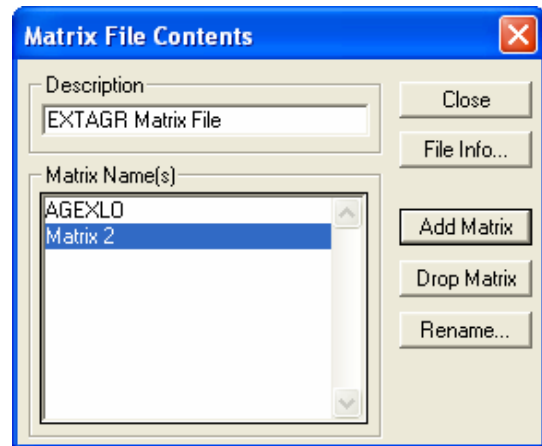


Figure 5.55. After Matrix Layer Added.

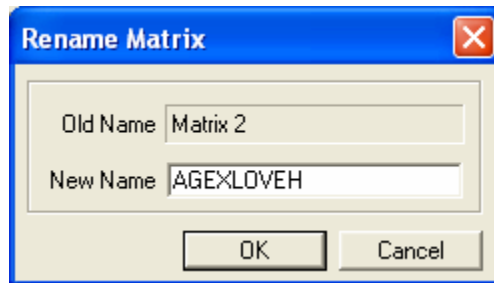


Figure 5.56. Renaming a Matrix Layer.

Switch to the new matrix layer by selecting it in the *Matrix to Display* pull-down area. The new matrix will be the same dimensions as the original matrix, but it will have no data in it. Figure 5.57 provides an example.

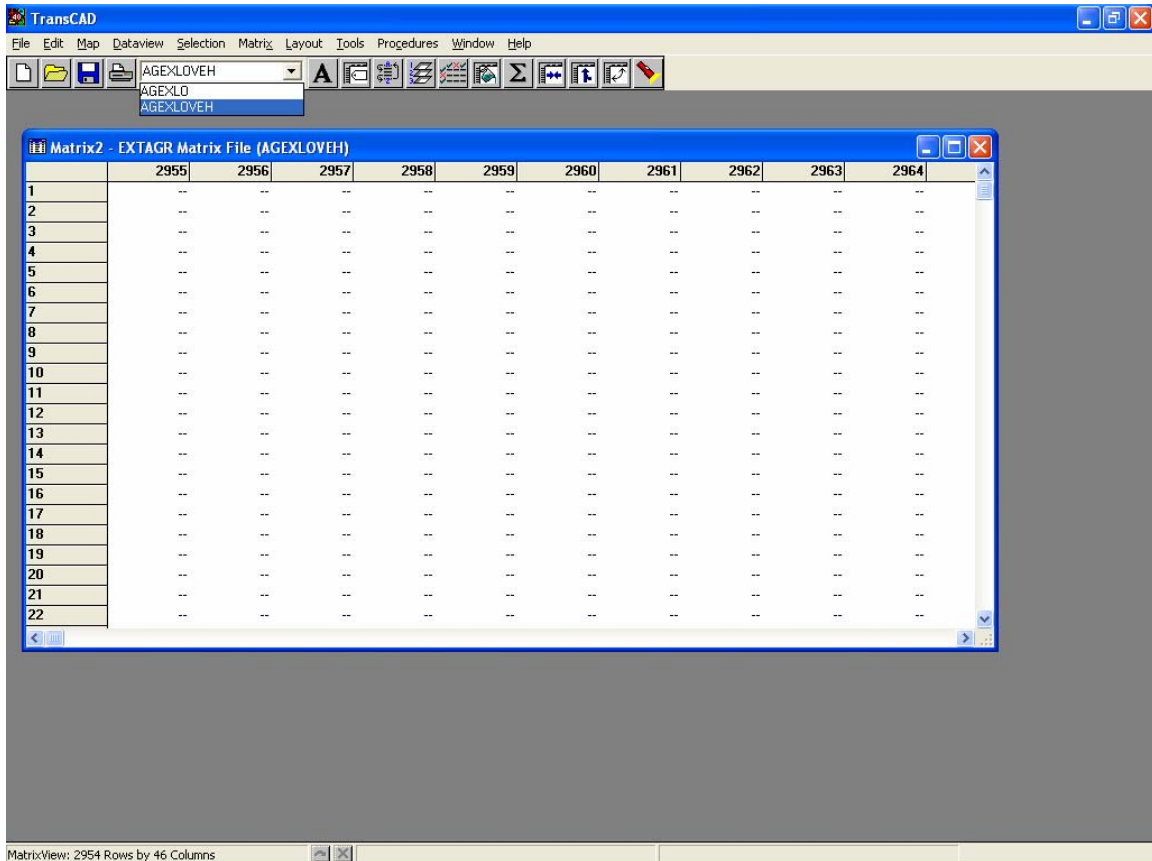


Figure 5.57. New Matrix Layer.

The next step is to convert the values in the original matrix (that are in tons) into vehicles. In order to do this a formula needs to be applied to all cells in the matrix that convert the tons in the original matrix into vehicles in the new matrix. Select *Matrix/Fill* from the TransCAD pull-down menu. A window will appear (shown in Figure 5.58) and the *Formula* tab should be selected. Next, select the original matrix layer in the first box under *Formula Builder* (AGEXLO in this example). Then select “/” in the second box. The user then must type the value for the conversion factor (to vehicles) for the respective commodity in the *Formula* field (in this example, the value is 16.36). Make sure that the *All* button under *Cells to Fill* is selected and then select *OK*. TransCAD will process the formula and insert the new values (in terms of vehicles) in the appropriate cells. Figure 5.59 provides an example of the matrix after applying the formula.

It is important to remember that each commodity matrix needs to be converted to vehicles prior to combining them into one matrix for all external-local and/or external-through movements.

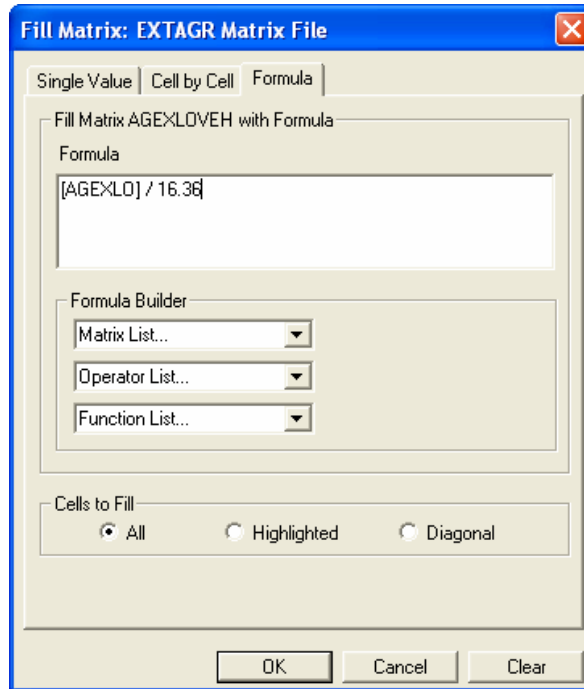


Figure 5.58. Converting Tons to Vehicles.

The screenshot shows the TransCAD software interface. The main window displays a matrix titled "Matrix2 - EXTAGR Matrix File (AGEXLOVEH)". The matrix has 29 rows and 11 columns. The columns are labeled 2984 through 2992, and the last column is labeled "Sum". The rows are labeled 1154 through 1174, and the last row is labeled "Sum". The matrix contains numerical values, mostly 0.00, with some non-zero values in the "Sum" column. The total sum for the matrix is 25.66.

	2984	2985	2986	2987	2988	2989	2990	2991	2992	Sum
1154	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
1155	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
1156	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
1157	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1158	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
1159	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
1160	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1161	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1162	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
1163	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
1164	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
1165	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
1166	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1168	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1169	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1170	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1171	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
1172	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1173	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
1174	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Sum	0.00	11.50	0.00	0.00	0.00	0.00	0.10	0.00	0.00	25.66

Figure 5.59. Example Matrix after Conversion to Vehicles.

After the 10 external-local and 10 external-through commodity groups have been converted to vehicles, the groups of 10 commodities must be combined into one matrix. In order to combine matrices, all the matrices that need to be combined must be opened. It is worth noting that each of the 10 matrix files has 2 layers, so the combining of files will create a new MTX file containing 20 layers. This action will result in a very large file.

To combine the 10 MTX files, open the 10 external-local (or external-through) files. Select **Matrix/Combine** and when a new window appears (Figure 5.60), select **Select All** and all of the files will become highlighted. Under **Options**, make sure **Keep all rows and columns** is selected. Then select **OK**, provide a file name for the new file, and TransCAD will begin to merge all of the selected files into one file (with multiple layers).

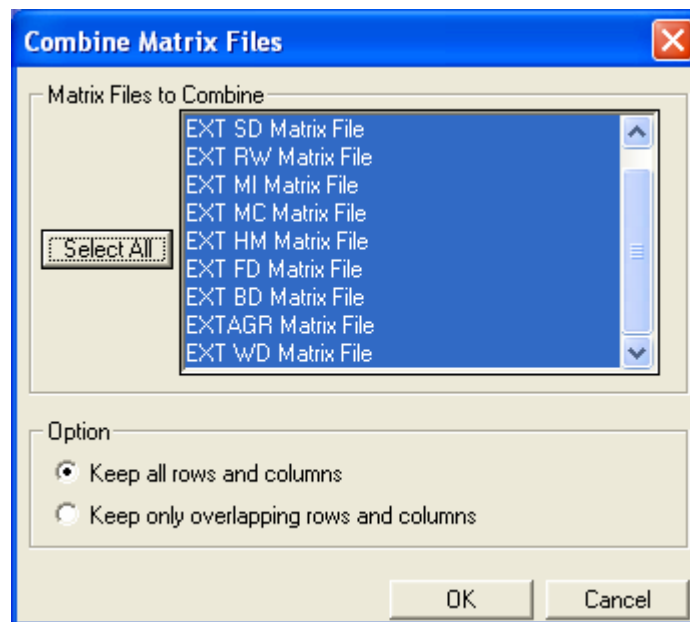


Figure 5.60. Combining Multiple MTX Files.

Figure 5.61 provides an example of the combined MTX file. Although all of the matrix layers are not visible in the *Matrix to Display* pull-down area, all of the matrix layers have been combined and are accessible in that menu.

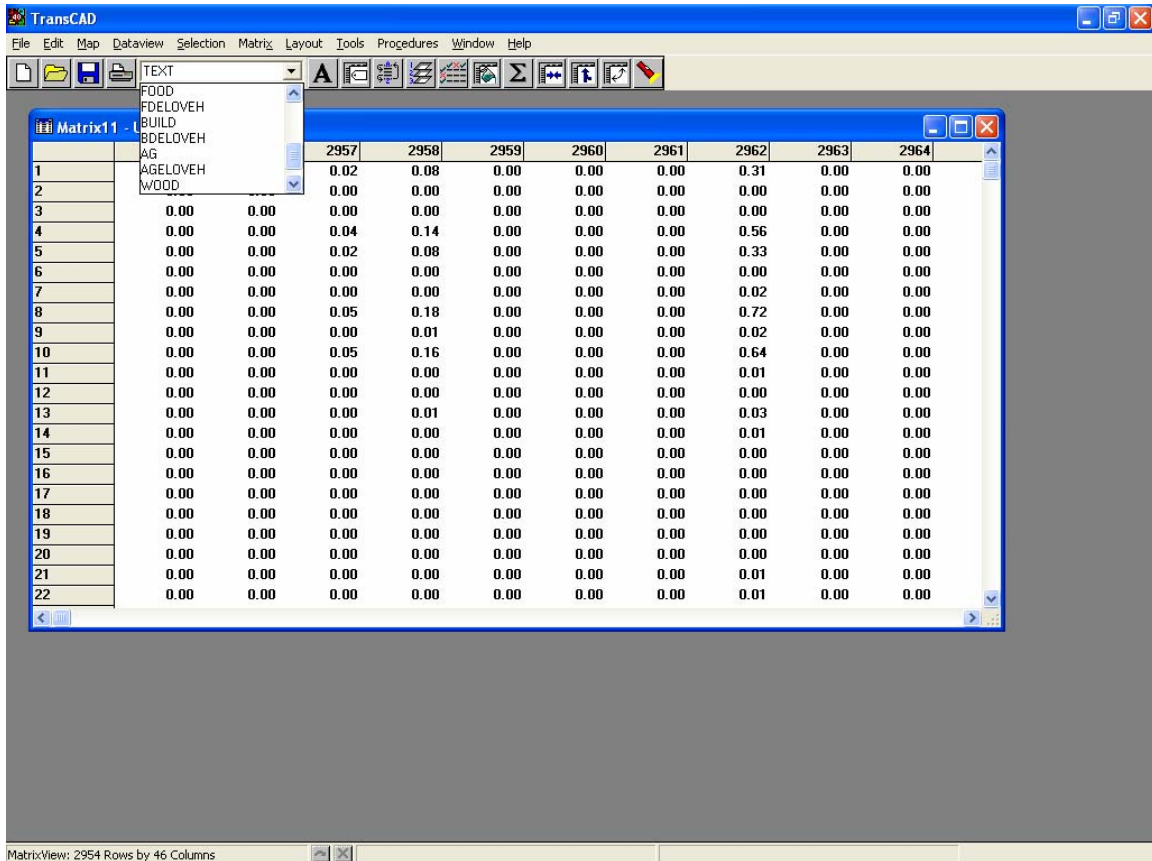


Figure 5.61. Example Combined Matrix (with 20 Layers).

Before summing the matrices, it is necessary to remove the layers that contain the commodity values that are in terms of tons. To do this, select **Matrix/Contents**. A box like the one shown in Figure 5.62 will appear. Highlight each layer containing ton values (in this example, it is any layer not ending in VEH). After highlighting the layer, select **Drop Matrix** and then **Yes** when the next box appears. This action will remove the layer.

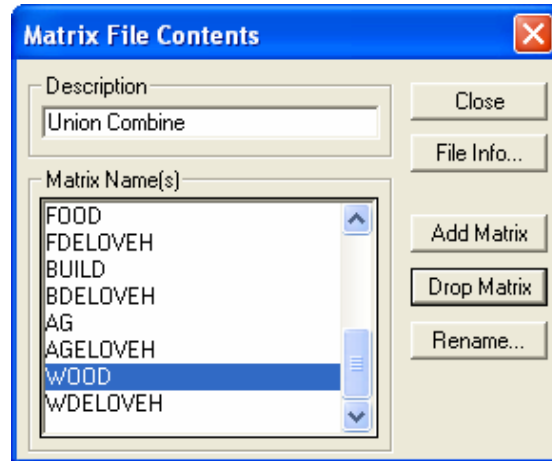


Figure 5.62. Removing Extra Matrix Layers.

The very first layer will not be able to be dropped from the matrix, but the values need to be removed since they will contain data in terms of tons of commodities. A method to work around this is to fill the cells for that matrix layer with zeros. To do this, make the first matrix layer the active matrix by selecting it from the *Matrix to Display* pull-down box. It is important that the proper layer is selected so that a layer with “good” data is not cleared. After switching to the appropriate matrix layer, select *Matrix/Fill*. A box will appear and an example is provided in Figure 5.63. On the *Single Value* tab, select the choice *Change cells to value* and insert the number 0 in the *Value* field. Make sure that *This matrix* under *Matrices to Fill* and *All* under *Cells to Fill* are selected as well. Select *OK* and TransCAD will replace all the cell values with 0.

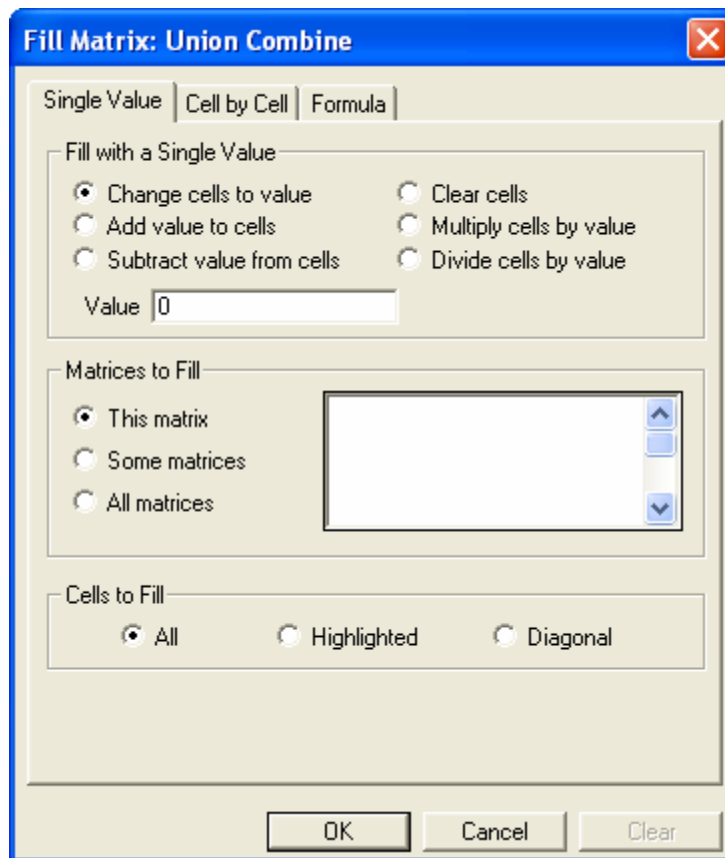


Figure 5.63. Filling Cells in Matrix.

Now the MTX file contains only vehicle values that can be aggregated by zones. To quickly sum all of the matrix layers into a new layer, select *Matrix/QuickSum*. Figure 5.64 provides an example of the QuickSum output. After performing the QuickSum feature, it is advisable to compare the layer total with the control total for the group to determine if the values are consistent.

With the QuickSum matrix active, select *Matrix/Copy*. In the box that appears (Figure 5.65), highlight the QuickSum layer and select *OK*. Enter a new file name at the prompt and select *Save*.

	2955	2956	2957	2958	2959	2960	2961	2962	2963	Sum
1	0.10	0.00	0.62	8.82	0.07	0.01	0.00	14.41	0.00	66.35
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.19	0.00	1.13	16.10	0.14	0.02	0.00	26.31	0.00	121.11
5	0.11	0.00	0.67	9.53	0.08	0.01	0.00	15.57	0.00	71.69
6	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.03	0.00	0.13
7	0.00	0.00	0.02	0.33	0.00	0.00	0.00	0.53	0.00	2.44
8	0.15	0.00	0.88	12.73	0.11	0.01	0.00	20.39	0.00	94.46
9	0.01	0.00	0.03	0.43	0.00	0.00	0.00	0.69	0.00	3.19
10	0.14	0.00	0.78	11.30	0.10	0.01	0.00	18.09	0.00	83.82
11	0.00	0.00	0.01	0.12	0.00	0.00	0.00	0.19	0.00	0.90
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.01	0.00	0.03	0.45	0.00	0.00	0.00	0.71	0.00	3.28
14	0.00	0.00	0.01	0.15	0.00	0.00	0.00	0.24	0.00	1.09
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.06
20	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.05
21	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.06	0.00	0.28
Sum	80.07	0.00	370.55	5117.32	57.90	6.60	0.00	8573.62	0.00	41188.72

Figure 5.64. Example of QuickSum Results.

With the QuickSum matrix active, select **Matrix/Copy**. In the box that appears (Figure 5.65), highlight the QuickSum layer and select **OK**. Enter a new file name at the prompt and select **Save**. The resulting matrix file should have one layer in it and be substantially smaller in terms of memory size.

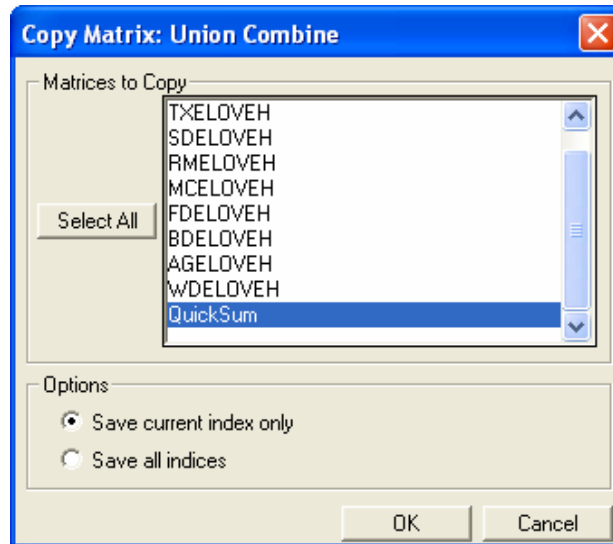


Figure 5.65. Copying QuickSum Matrix.

This process should be performed for both the external-local and external-through commodities. After this is done, the user should have two MTX files with each file containing the total vehicular movements for the respective groups. Next, the SAM and internal movement matrices need to be developed. The following section will discuss the method to accomplish this action.

Importing Non-External Data-Sets

The process for importing non-external group data-sets is different than the external groups. The data for these four groups are all in the same format (3I8), but some of the data is represented in terms of weight (SAM and Urban Internal) and others are in terms of vehicles (Urban Empty Vehicles and Urban Non-Transfer Vehicles). The process for importing the files into matrix format will be the same; however, the groups that are in terms of weight will need to be converted into vehicles.

To import a 3I8 file into a matrix, select *TxDOT/Import/Import ASCII 3I8 Trip Table* from the TransCAD pull-down menu. A dialog box like the one shown in Figure 5.66 will appear.

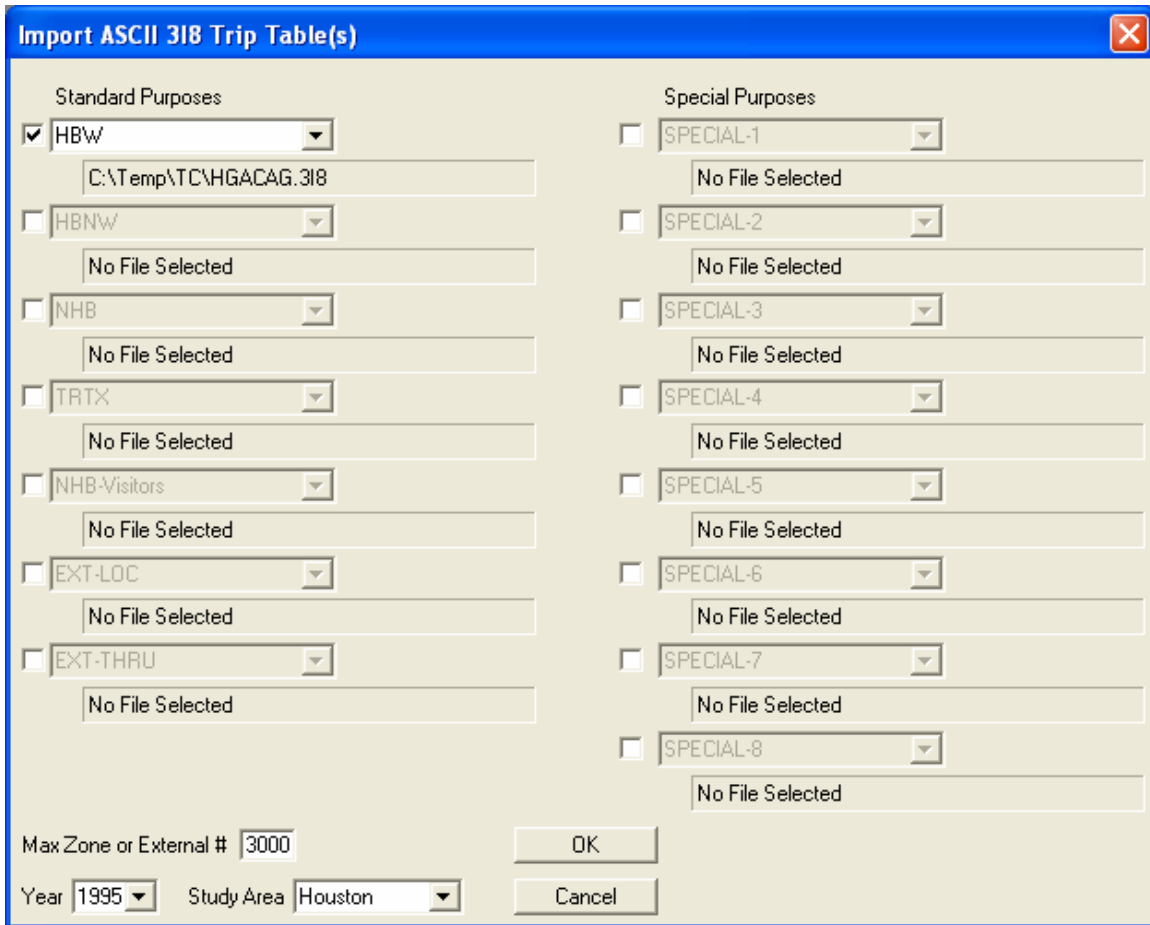


Figure 5.66. Importing 3I8 File into Matrix.

When one of the boxes next to the trip purposes is checked, another box will appear. Use this box to locate and select the 3I8 file to be imported. After selecting the file to be imported, the second box will close and return the user to the first box. It is important that the information at the bottom-left of this box is filled in as well. Enter the maximum external zone value for the study area, the year that the source data are for, and the study area being analyzed. When “OK” is selected, the user will be prompted to supply a name for the matrix file that is about to be created. Again, it is advisable to use a name that is descriptive of the data-set. After a file name is specified and entered, TransCAD will process the 3I8 data and produce a matrix file.

This process should be repeated for each of the 3I8 input files in each of the four non-external groups. At this point in the freight modeling process there were:

- SAM commodities (eight matrices measured in quarter tons);
- Urban commodities (10 matrices measured in quarter tons);

- Urban Empty Vehicles (one matrix measured in terms vehicles); and
- Urban Non-Transfer Vehicles (10 matrices measured in terms of vehicles).

The last two groups (empty vehicles and non-transfer vehicles) do not need to be converted since they are already measured in terms of vehicles. However, both the SAM and Urban commodity files need to be converted to number of vehicle trips. The process for performing this is similar to the process utilized in converting the external matrices from a weight to vehicle unit of measurement. These two groups, unlike the external groups, were measured in terms of quarter tons.

Quarter tons were used as a result of issues that arose in the initial trip distribution process. Originally, tons were used as the unit of measurement, but due to the large matrix size for the network (3000 x 3000 zones or 9,000,000 cells) the distribution process could not distribute smaller commodity amounts efficiently. Next, using pounds as the unit of measurement was considered. However, the trip generation phase of the model could not process those cells with a large amount of certain commodities.

The next step is to convert the values in the original matrix (that are in quarter tons) into tons and then into vehicles. In order to accomplish this, a second matrix must be created within the MTX file. This process is identical to the process used for the external data-sets. Select *Matrix/Contents* and a new box will appear. Then select *Add Matrix* and click on *Matrix 2* (this will highlight it). The *Rename* button will activate when *Matrix 2* is highlighted. Select *Rename* and enter the desired name for the matrix layer in the box that appears. Then select *OK*. As with other phases of the process, it is a good idea to be descriptive with the layer name.

Now there is a new matrix layer within the MTX file that can be used to perform the conversions. In order to convert the data from the original/base layer of the matrix, a formula needs to be applied to all cells in the matrix. The formula will convert the quarter ton values in the original matrix into tons in the new matrix. Select **Matrix/Fill** from the TransCAD pull-down menu. A window will appear (shown in Figure 5.67) and the **Formula** tab should be selected. Next, select the original matrix layer in the first box under **Formula Builder** (HBW in this example). Then select “/” in the second box. The user may type the number “4” in the **Formula** field. Ensure that the **Cells to Fill** button for **All** is selected and then select **OK**. Every commodity that is measured in quarter tons should be divided by four to convert to tons.

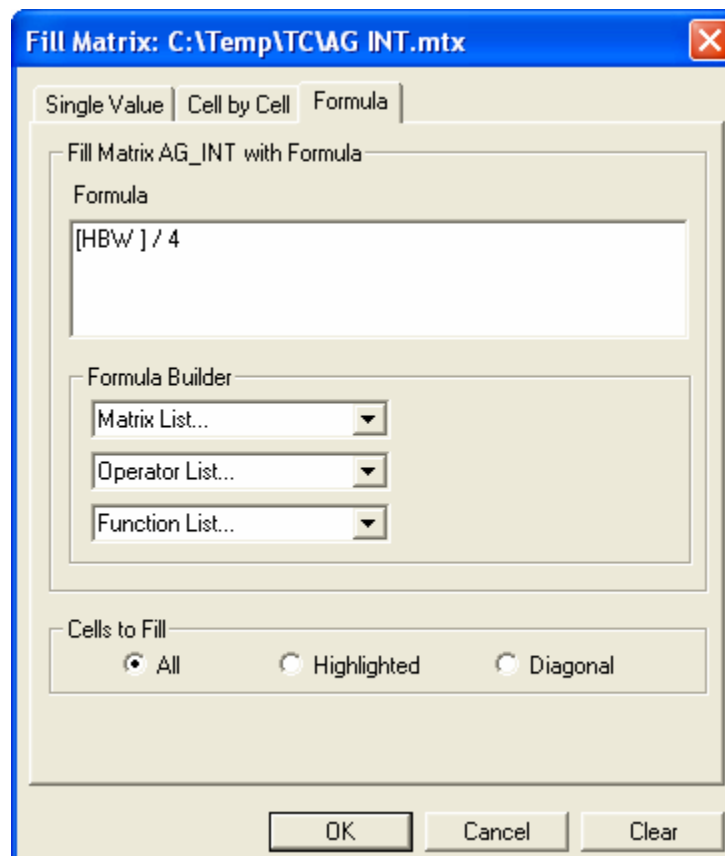


Figure 5.67. Converting Quarter Tons to Tons.

At this point, the quarter ton values have been converted to tons. Next, the tons need to be converted to vehicles. Each commodity will have a conversion factor that should be applied to the ton values for each cell. To accomplish this, the same “fill” process is used. The main difference in this conversion is that the user needs to specify the second matrix layer (the one with values in terms of tons) when entering the formula information. Figure 5.68 provides an example. In this example, the second matrix layer is named AG_INT and the conversion factor is 2.87.

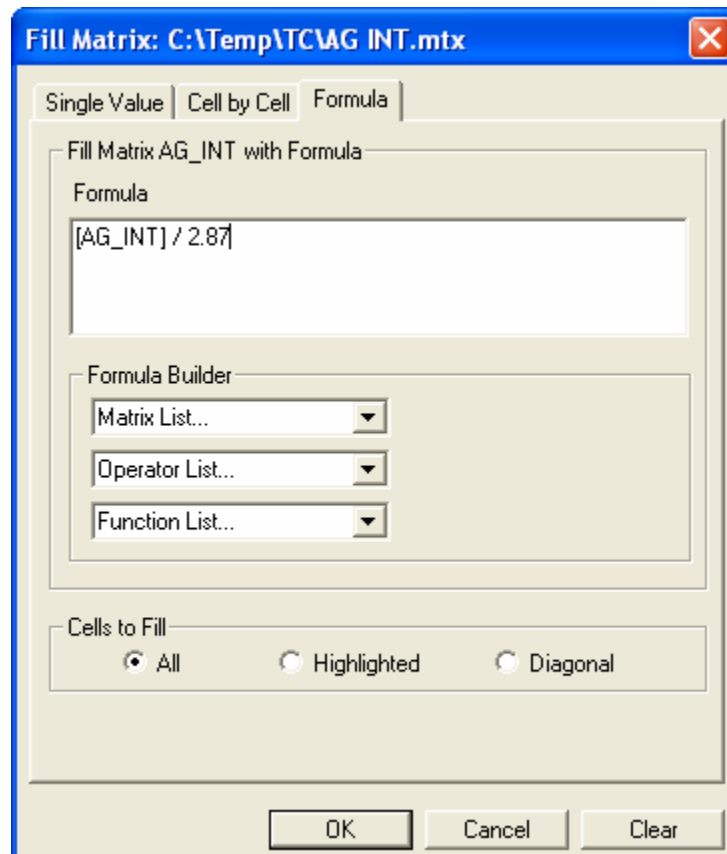


Figure 5.68. Converting from Tons to Vehicles.

This process should be repeated for all of the commodities in the SAM and Urban Internal groups. Again, it is important to remember that each commodity has a different conversion factor when converting from tons to vehicles. It is also advisable to check the control totals for each commodity after the conversion is performed to ensure that the proper factors were used. The conversion factors for converting tons of each commodity type to truck trips are shown in Table 5.38. The assumed factor for the external local and external through movements were based on data from Florida representing over-the-road load factors. The assumed factors for internal movements were based on the average shipping loads as estimated from the analysis of the commercial vehicle survey data for the HGA.

After performing this process on all of the SAM and Urban Internal commodities, all of the non-external matrices should contain values that are in terms of vehicles. Now the process of combining the matrices can begin.

Combining Non-External Data-Sets

The process used to combine matrices is essentially the same as the one used for combining the external-local and external-through matrices. However, the matrices for the two groups that were originally in quarter tons will have an extra layer in the MTX file. As a result, the following information will provide information on how to combine each of the four groups individually.

Table 5.38. Assumed Loading Factors for Commodity Movements.

Commodity Group	Internal Movements (Tons Vehicle)	External Movements (Tons/Vehicle)
Agriculture	0.80	16.36
Raw Materials	8.82	19.48
Food	2.87	18.23
Textiles	0.52	8.68
Wood	2.02	14.57
Building Materials	5.83	18.47
Machinery	1.00	11.38
Miscellaneous	2.24	12.44
Secondary	1.35	9.07
Hazardous Materials	2.37	12.54

Combining SAM Matrices

In the freight model, there are eight SAM matrices (in terms of trips by commodity type) and each matrix has two layers. As a result, when combining the matrices, the new MTX file contains 16 layers. The process for combining the matrices and obtaining one matrix with one layer is the same as used for the external groups. The process is summarized below.

1. Open all SAM trips by commodity matrix files (eight files).
2. Select **Matrix/Combine**.
3. Click **Select All**.
4. Check **Keep all rows and columns** (should be the default).
5. Select **OK**.
6. Provide a file name for the new combined matrix file.
7. Select **Save**.
8. After creating the new matrix, close all individual matrices (leaving only the combined matrix open). In this example, the matrix will have 16 layers.
9. Select **Matrix/Contents**
10. Highlight a non-vehicle layer by clicking on it.
11. Select **Drop Matrix** and then **Yes**.

12. Repeat steps 1-11 for all the other non-vehicle layers (except the first one, which can not be dropped). After completing this, there are nine layers in the example (eight vehicle layers and one layer in quarter tons).
13. Close the **Matrix Contents** window.
14. Select the first matrix layer (the one in terms of quarter tons) from the **Matrix to Display** pull-down menu. It is very important that the correct layer is active before performing the fill function.
15. Select **Matrix/Fill**.
16. Select the **Single Value** tab (it should come up on this tab).
17. Select **Change cells to value** and enter '0' in the **Value** field. **This matrix** and **All** should also be checked.
18. Select **OK** (all of the values in this matrix should be zeroed out).
19. Select **Matrix/QuickSum**.
20. Check QuickSum total against control total.
21. With QuickSum matrix active, select **Matrix/Copy**.
22. Highlight the QuickSum layer and click **OK**.
23. Enter file name for the new matrix file and select **Save**.
24. The new matrix file will contain one layer that is all of the SAM trips combined.

Combining Urban Internal Matrices

In the freight model, there are 10 urban internal matrices (in terms of trips by commodity type) and each matrix has 2 layers. As a result, when the matrices are combined, the new MTX file contains 20 layers. The process for combining the matrices and obtaining one matrix with one layer is the same as used for the SAM group. The process is summarized below.

1. Open all Urban Internal trips by commodity matrix files (10 files).
2. Select **Matrix/Combine**.
3. Click **Select All**.
4. Check **Keep all rows and columns** (should be the default).
5. Select **OK**.
6. Provide a file name for the new combined matrix file.
7. Select **Save**.
8. After creating the new matrix, close all individual matrices (leaving only the combined matrix open). In this example, the matrix will have 20 layers.
9. Select **Matrix/Contents**.
10. Highlight a non-vehicle layer by clicking on it.
11. Select **Drop Matrix** and then **Yes**.
12. Repeat steps 1-11 for all the other non-vehicle layers (except the first one, which cannot be dropped). After completing this, there are 11 layers in the example (10 vehicle layers and one layer in quarter tons).
13. Close the **Matrix Contents** window.
14. Select the first matrix layer (the one in terms of quarter tons) from the "Matrix to Display" pull-down menu. It is very important that the correct layer is active before performing the fill function.
15. Select **Matrix/Fill**.
16. Select the **Single Value** tab (it should come up on this tab).

17. Select ***Change cells to value*** and enter “0” in the ***Value*** field. ***This matrix*** and ***All*** should also be checked.
18. Select ***OK*** (all of the values in this matrix should be zeroed out).
19. Select ***Matrix/QuickSum***.
20. Check QuickSum total against control total.
21. With the QuickSum matrix active, select ***Matrix/Copy***.
22. Highlight the QuickSum layer and click ***OK***.
23. Enter the file name for the new matrix file and select ***Save***.
24. The new matrix file will contain one layer that is all of the Urban Internal trips combined.

Combining Urban Empty Vehicles

The urban empty vehicle group was comprised of only one matrix in terms of vehicle trips, and therefore no combining of files is needed.

Combining Urban Non-Transfer Vehicle Matrices

In the freight model, there are 10 non-transfer vehicle matrices (in terms of trips by commodity), but each matrix has only a single layer. When the matrices are combined, the new MTX file contains 10 layers. The process for combining the matrices and obtaining one matrix with one layer varies slightly from the other groups. The process is summarized below.

1. Open all Urban Non-Transfer trips by commodity matrix files (10 files).
2. Select ***Matrix/Combine***.
3. Click ***Select All***.
4. Check ***Keep all rows and columns*** (should be the default).
5. Select ***OK***.
6. Provide a file name for the new combined matrix file.
7. Select ***Save***.
8. After the new matrix is created, close all individual matrices (leaving only the combined matrix open). In this example, the matrix will have 10 layers.
9. Select ***Matrix/QuickSum***.
10. Check QuickSum total against control total.
11. With the QuickSum matrix active, select ***Matrix/Copy***.
12. Highlight the QuickSum layer and click ***OK***.
13. Enter the file name for the new matrix file and select ***Save***.
14. The new matrix file will contain one layer that is all of the Urban Non-Transfer trips combined.

When all of the processes listed above have been performed, there are six matrix files (each with one layer) ready to be combined and eventually used to perform a traffic assignment. The six files are:

- Combined SAM trips,
- Combined Urban Internal trips,
- Urban Empty Vehicle trips,
- Combined Urban Non-Transfer Vehicle trips,

- Combined External-Local trips, and
- Combined External-Through trips.

The process for aggregating these six files is similar to that which was referenced in prior sections. However, the external groups have matrices that are different dimensions than the other groups, and as a result, an additional process must be undertaken. The following section describes the process.

Aggregating Combined Matrices

The order in which the combined matrices can be aggregated is not critical. However, care should be taken with the files in order to preserve the data integrity. The process that is shown below represents the method that was used in preparing the freight model data for input into the traffic assignment phase.

The first step in developing a “master” matrix with all of the groups combined involves adding the external-local and external-through combined matrices. There is a subtle difference to these 2 combined matrix files. The difference is that they are both different dimensions than the other 4 combined matrix files. In the Houston example, there are 3000 zones. So a full matrix is 3000 by 3000 cells. However, this number includes both the internal and external zone. In Houston, 46 of the zones are externals. As a result, the external-local matrix is 2954 by 46 cells and the external-through matrix is 46 by 46 cells.

To add the external-local combined matrix to the Urban Internal combined matrix, both of the matrix files need to be open. With the Urban Internal combined matrix the active matrix, select **Matrix/Update**. A window like the one shown in Figure 5.69 will appear. The name of the external-local combined matrix should be entered into the first cell under **Matrix File**. After this cell is filled in, the cell to the right of it (“Matrix”) will activate. This cell should contain the Urban Internal matrix name (this should be the only available choice to fill the cell). After the cells are filled in, select **OK** and TransCAD will begin to insert the external-local values into the Urban Internal combined matrix.

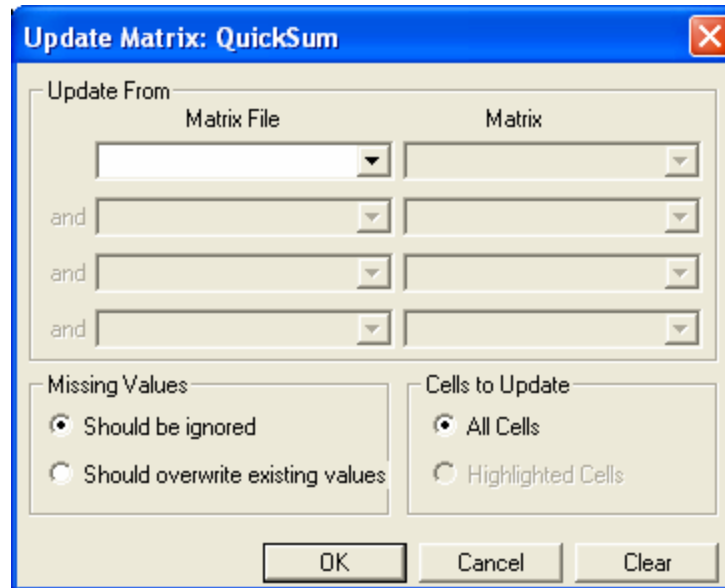


Figure 5.69. Matrix Update Feature.

After completing the processing, close the external-local combined matrix and open the external-through combined matrix. To add the external-through combined matrix, follow the same process used for the external-local combined matrix. When this is done, the Urban Internal combined matrix will contain all of the external related trips. At this point, the three remaining matrices (SAM, Urban Non-Transfer, and Urban Empty Vehicle) can be combined with the Urban Internal matrix. The process to combine the matrices follows:

1. Open the 4 matrix files.
2. Select **Matrix/Combine**.
3. Click **Select All**.
4. Check **Keep all rows and columns** (should be the default).
5. Select **OK**.
6. Provide a file name for the new “master” matrix file.
7. Select **Save**.
8. After creating the new matrix, close all individual matrices (leaving only the combined matrix open). In this example, the matrix will have four layers.
9. Select **Matrix/QuickSum**.
10. Check QuickSum total against control total.

11. With the QuickSum matrix active, select *Matrix/Copy*.
12. Highlight the QuickSum layer and click *OK*.
13. Enter the file name for the new matrix file and select *Save*.
14. The new matrix file will contain one layer that contains all of the trips combined.

When the combining and copying process is complete, the file that is created is the “master” file that contains all of the truck trip information for the urban area. This is the file that will be used as an input to the traffic assignment. The next section provides information on running a traffic assignment.

TRAFFIC ASSIGNMENT

The “master” matrix that was prepared in the previous steps represents a trip table of vehicular movements between zones in the urban area in terms of productions and attractions (P-A). Prior to running a traffic assignment, the P-A table must first be converted to an O-D table. To accomplish this, first the transportation network layer and the P-A matrix must be open, with the network layer being the active layer. Next, select *Planning/P-A to O-D* from the TransCAD menu. A window similar to the one shown in Figure 5.70 will appear. Since the “master” matrix contains only one layer, most of the default information shown in the window will not need to be modified. If there are multiple matrices open or several matrix layers open, the layer containing the “master” matrix data must be specified in the *Matrices* field. Additionally, the box next to *Report each hour separately always* needs to be unchecked. After doing this, select *OK* and there will be a prompt to enter a name for the new file. The default file saved name is PA2OD.MTX. It is advisable to add the study area name and the current date to this name. After entering a new file name and selecting *Save*, the process will execute and produce a new O-D matrix. The P-A matrix may be closed at this point.

Convert P-A Matrix to O-D Matrix ✖

Input

P-A Matrix File: ALL_VEHICLES

Lookup Dataview:

Report Hours: 0 To 24

Report each hour separately

Change Information

Matrices	Use	Vehicle Trips
URB+SAM	Yes	No

Use Matrix URB+SAM

Hourly Percent Departure:

Hourly Percent Return:

Convert person trips to vehicle trips

Average Occupancy: 1.5

Hourly Adjustment:

OK
Cancel
Settings

Figure 5.70. Converting P-A to O-D.

With the network layer and the O-D matrix both open (and the network layer as the active layer), select **Planning/Traffic Assignment**. A window similar to the one shown in Figure 5.71 will open.

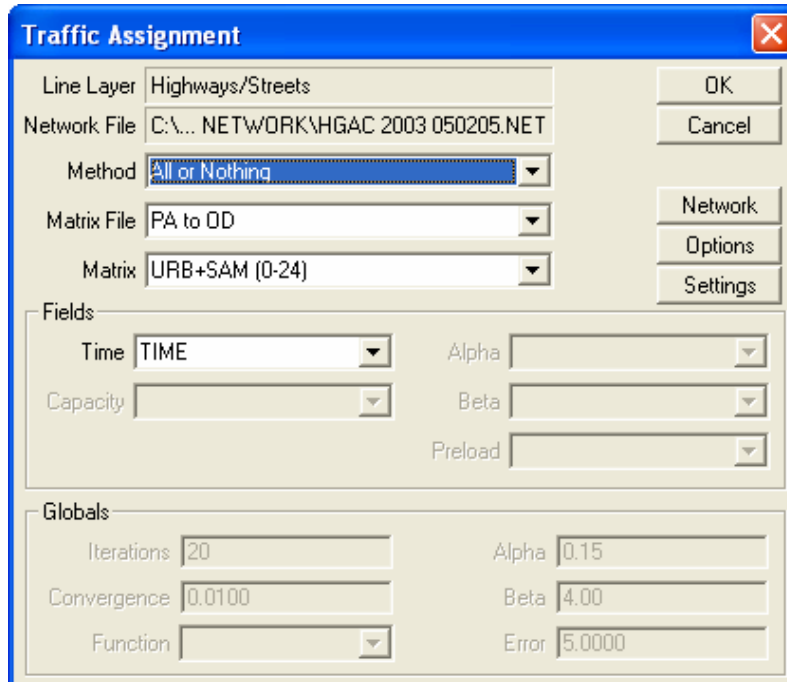


Figure 5.71. Running a Traffic Assignment, Main Screen.

If the O-D matrix is the only matrix file open, the only information in this window that must be modified is the assignment method. For the freight model, an “all-or-nothing” method was utilized. Select that method from the pull-down menu next to **Method**. Then select the **Network** button. When this button is selected, a window similar to the one shown in Figure 5.72 will appear. On the **Info** tab (which is the default tab that should appear), the **Centroids** box needs to be checked. After that is checked, select the **Other Settings** tab. Figure 5.73 shows the tab. Select the **In Selection Set** option, and from the pull-down menu, choose the selection set that contains the centroids for the area. A selection set for the centroids was created prior to building the separation matrix. After identifying the centroid selection set, select **OK**. **OK** should also be selected again in the next window. A prompt for a new file name will appear (the default name is ASN_LINKFLOW.BIN). After entering a new file name for the assignment, select **Save**. The assignment process will execute and the results of the assignment will be displayed on the TransCAD screen.

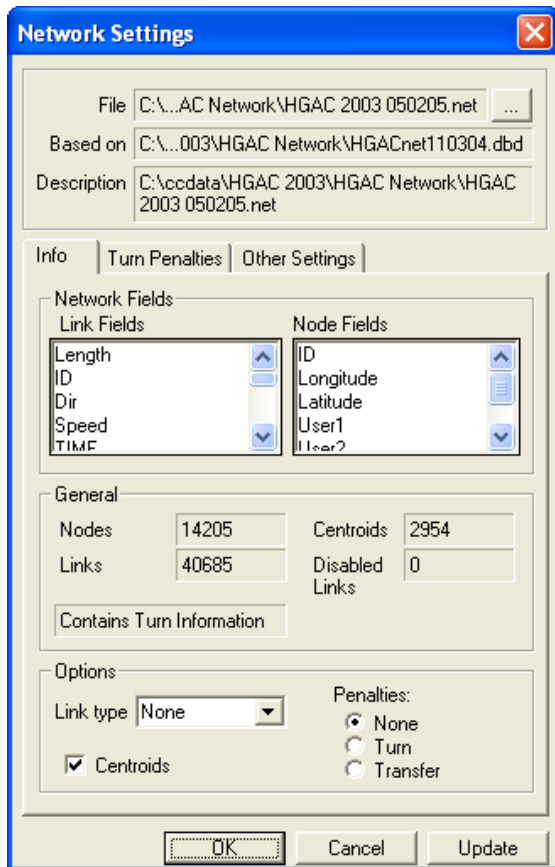


Figure 5.72. Network Settings.

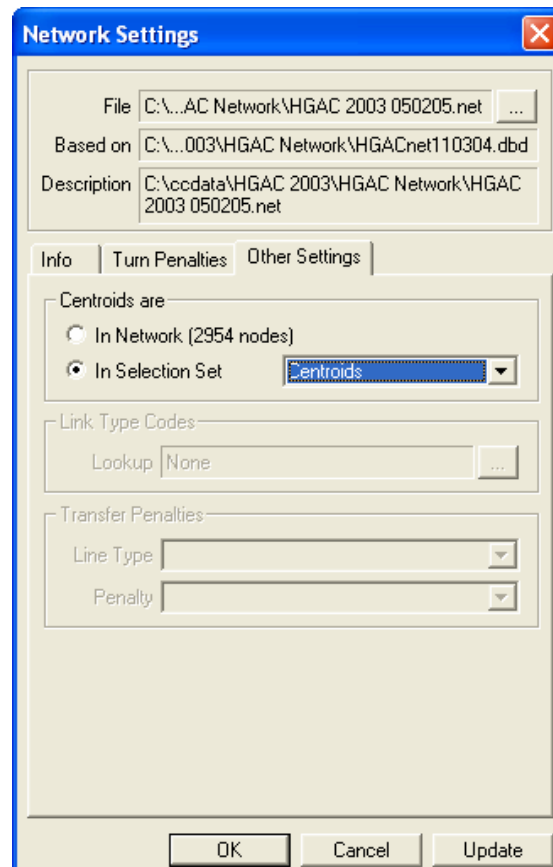


Figure 5.73. Other Settings.

Figure 5.74 provides an example of the output from the traffic assignment. The output provides directional flows, times, and speeds by link. After the traffic assignment is run, the assigned flows appear as a joined dataview with the network layer link data. At this point it is possible to conduct analyses of the assignment process.

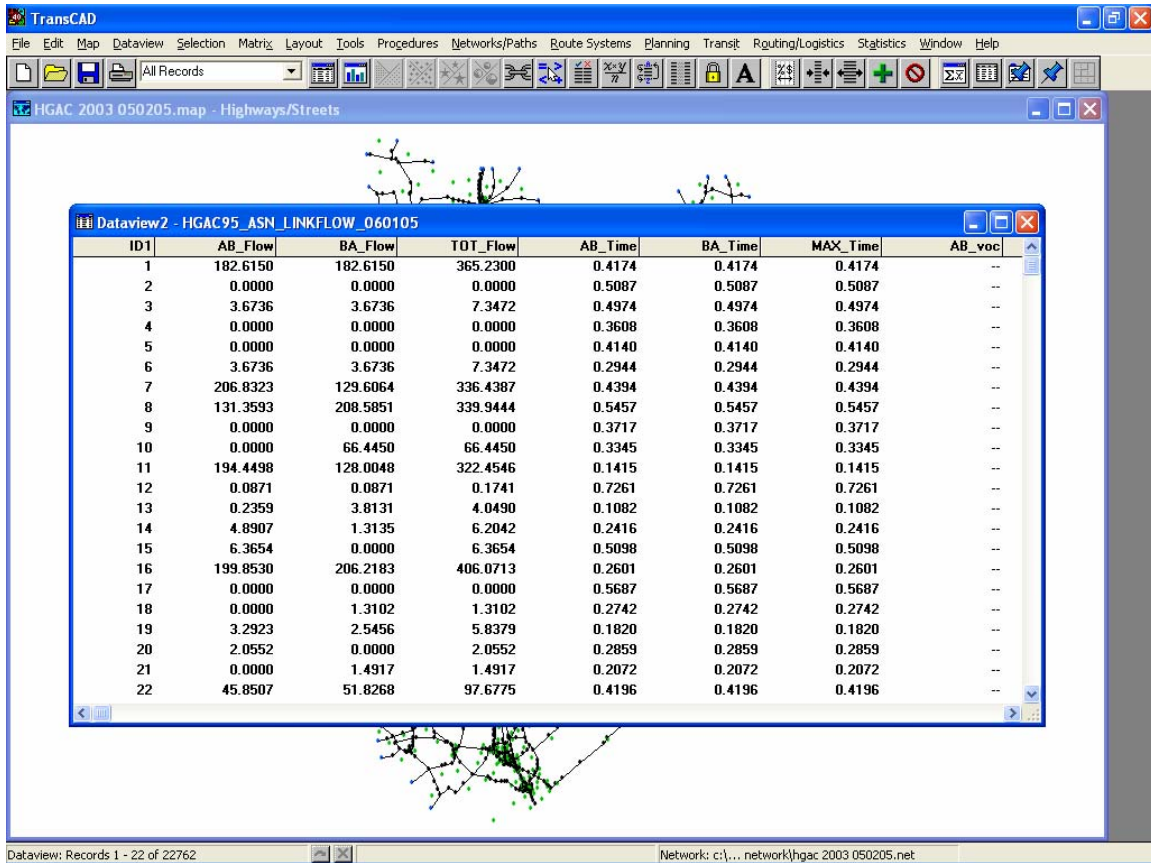


Figure 5.74. Traffic Assignment Output.

Analysis of Traffic Assignment

After running a traffic assignment, keep the joined dataview open. From the TransCAD pull-down menu list, select *TxDOT/Assignment Utilities/Valid8*. The Valid8 program interface will appear (see Figure 5.75). Fill in the fields with the appropriate column names from the joined dataview. In order for the program to run properly, all of the fields must have a value filled in. After the fields are filled in, select *OK*. A prompt to name the file will appear. After naming the new file, select *Save* and the program will run. After Valid8 runs, an output file will appear on the screen.

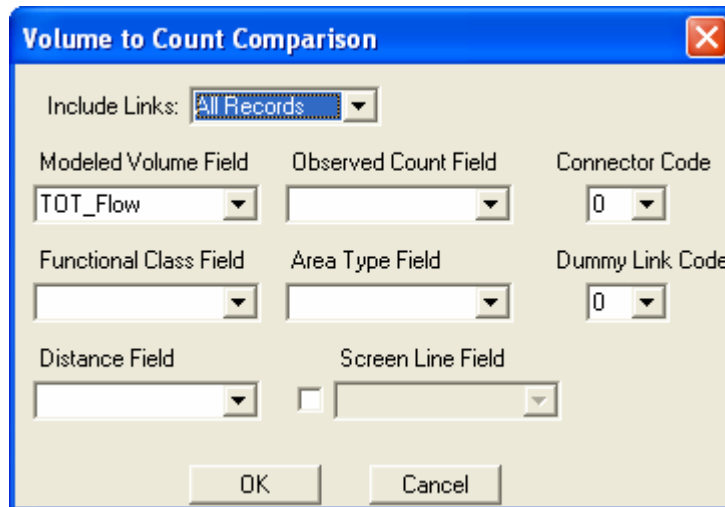


Figure 5.75. Valid8 Interface.

The Valid8 output will provide a variety of information on the traffic assignment. For the purpose of the freight model, an important output of the assignment was the modeled VMT. This information can be obtained from the Valid8 output file, and an example is provided in Figure 5.76.

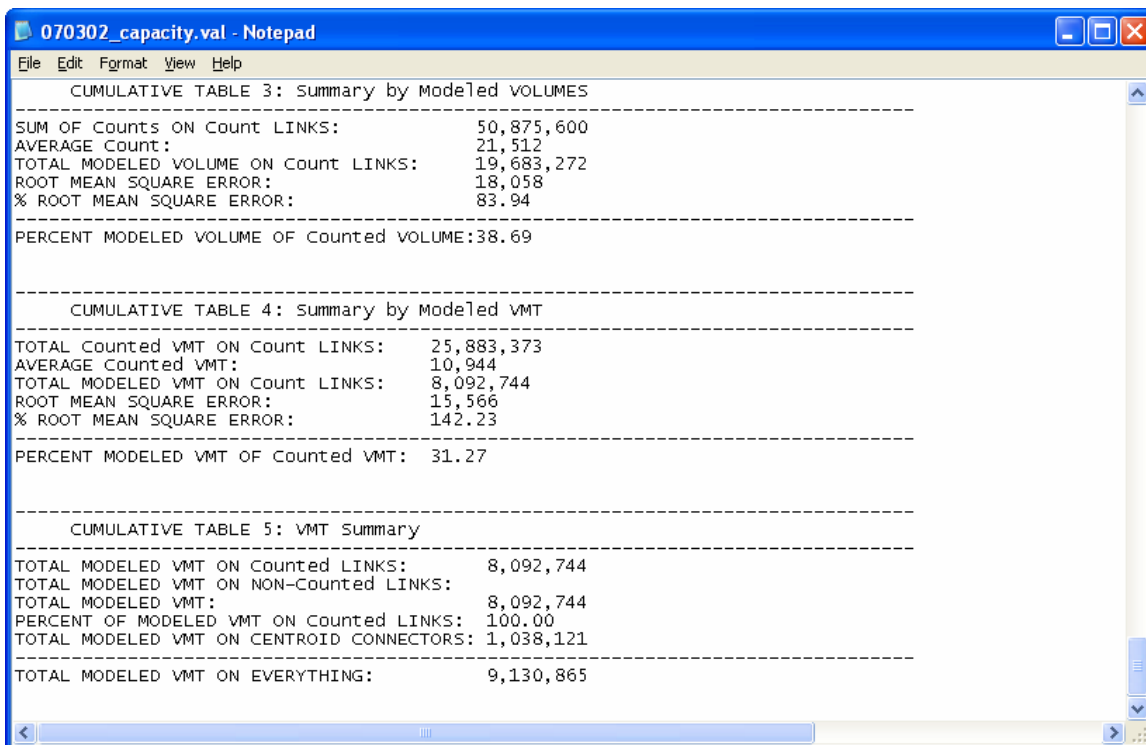


Figure 5.76. Example Valid8 Output File.

SUMMARY OF MODEL RESULTS FOR HGA

The previous sections have described in considerable detail the steps and processes involved in integrating the SAM truck freight model into the urban model application for HGA and applying an urban commodity/truck model for HGA. Note these applications were only for commodities being transported by trucks. The applications used data and software currently utilized by TxDOT in their urban travel demand models. The data and results presented in this section are the final estimates that were produced after making adjustments to attempt to calibrate the model. These adjustments were made to the assumptions in the generation phase dealing with percentages of vehicle weight used to estimate cargo load weights and the percentages of truck trips being made by cargo transport vehicles.

Table 5.39 presents a summary of the commodity movements as estimated in the SAM, in the urban model, and as developed from the SAM based on the critical link analyses.

Table 5.39. Summary of Commodity Movements (Daily Tons).

Commodity Group	Internal Movements		External Movements		
	SAM	Urban Model	SAM From Internal	SAM To Internal	SAM EE
Agriculture	85	1427	2518	2917	2538
Raw Materials	39,978	110,580	246,653	110,562	29,918
Food	6248	22,194	33,645	62,977	8678
Textiles	304	1869	15,763	48,189	6132
Wood	2550	5560	2884	6749	4242
Building Materials	11,256	136,161	48,128	79,470	10,030
Machinery	530	9336	9409	20,537	6932
Miscellaneous	-	26,034	-	-	-
Secondary	16,020	2867	63,454	54,883	3529
Hazardous Materials	-	2946	-	-	-
Totals	76,961	318,974	422,454	386,284	71,999

Internal truck trips that did not transfer cargo were estimated as well as the number of empty truck trips. The number of vehicle trips made that did not involve a transfer of cargo was estimated to be 47,857. The number of vehicle trips made where the vehicle was empty and not carrying any cargo was estimated to be 60,291. Note that these estimates do not include any commercial service vehicles. Table 5.40 converts the commodity movements shown in Table 5.39 to the estimated equivalent in vehicle movements based on average load factors by commodity type.

An estimated 273,484 truck trips were assigned to the HGA highway and street network using the all or nothing assignment option. The resulting estimate of truck VMT was 5.5 million. Data received from Mark Hodges with TxDOT TPP estimates the daily truck on-system VMT in the HGA at 5.73 million in 1998. It should be noted that the estimate from TxDOT does not include off-system VMT and if that estimate was available, the total truck VMT would be higher. It should also be noted that the estimate produced in the model presented in this research only represents the VMT for cargo transport commercial vehicles. This estimate is, therefore, expected to be less than the TxDOT estimate due to the unknown effect of non-cargo transport commercial vehicles. The estimated total VMT from the commodity model does appear to be reasonable. It should be noted that the external related truck estimates account for an estimated 3 million of the 5.5 million total truck VMT. This estimate represents nearly 55 percent of the total VMT related to cargo transport trucks.

Table 5.40. Summary of Vehicle Movements (Estimated Daily Trips).

Commodity Group	Internal Movements		External Movements		
	SAM	Urban Model	SAM From Internal	SAM To Internal	SAM EE
Agriculture	106	1,784	154	178	155
Raw Materials	4,543	12,566	12,662	5,676	1,536
Food	2,154	7,653	1,846	3,455	476
Textiles	608	3,738	1,816	5,552	706
Wood	1,275	2,780	198	463	291
Building Materials	1,941	23,476	2,606	4,303	543
Machinery	530	9,336	827	1,805	609
Miscellaneous	-	18,834	-	-	-
Secondary	11,443	2,048	6,996	6,051	389
Hazardous Materials	-	1,228	-	-	-
Totals	22,600	83,443	27,105	27,483	4,705

A total of 57 vehicle classification counts were available for comparison of assigned volumes to counted volumes on the HGA 1998 network. Table 5.41 presents this comparison sorted by worst under-assigned volume to worst over-assigned volume. While this comparison is of interest, it does not present any conclusive evidence as to whether the estimates are good or bad. Essentially, the individual link comparisons show both good and bad results. There were not enough counts in the right locations to permit any detailed corridor evaluation of assigned volumes versus counts. The overall results in terms of estimated commodities and truck VMT appear reasonable given the number of assumptions and limited data available for calibrating the model. The model concept and process appear valid and produce what are considered reasonable estimates of the total commodities being shipped and received in the HGA and successfully integrates the SAM estimates into the urban modeling framework.

Table 5.41. Comparison of Counted and Assigned Truck Volumes.

Truck Count	Assigned Volume	Percent Difference	Truck Count	Assigned Volume	Percent Difference
2161	76	-96.5	8352	5911	-29.2
7027	392	-94.4	2947	2126	-27.9
1077	65	-94.0	1118	833	-25.5
809	64	-92.1	7671	5982	-22.0
478	40	-91.6	984	784	-20.3
23	2	-91.3	8071	6630	-17.9
2321	215	-90.7	10,794	9222	-14.6
2116	216	-89.8	12,860	11,036	-14.2
361	39	-89.2	50	45	-10.0
523	69	-86.8	10,253	9384	-8.5
5770	992	-82.8	1521	1393	-8.4
16,070	2900	-82.0	13,314	12,401	-6.9
1497	282	-81.2	13,214	12,969	-1.9
2030	483	-76.2	12,880	13,645	5.9
2653	689	-74.0	9570	10,413	8.8
13,212	4323	-67.3	9104	10,417	14.4
808	271	-66.4	5489	6315	15.0
1991	744	-62.6	12,233	14,085	15.1
4167	1969	-52.7	1482	1755	18.4
12,418	6064	-51.2	1118	1348	20.6
14,276	6978	-51.1	8854	11,152	26.0
1884	958	-49.2	1524	1924	26.2
1622	874	-46.1	5261	7987	51.8
1464	816	-44.3	7103	10,888	53.3
14,757	8849	-40.0	8025	12,377	54.2
5550	3675	-33.8	160	345	115.6
15,236	10,136	-33.5	1472	4648	215.8
8668	5867	-32.3	2202	7383	235.3
15,951	11,057	-30.7			

CHAPTER 6 – FINDINGS AND RECOMMENDATIONS

This research has focused on two primary objectives. One was the evaluation of the Texas SAM with other statewide modeling efforts relative to freight and commodities. The second was the development of a comprehensive commodity/freight model for use in urban areas that would integrate the results of the Texas SAM into the urban travel demand modeling efforts. Both objectives were achieved. The purpose of this chapter is to present these findings and recommendations for further improvements.

TEXAS SAM

The Texas SAM estimates and forecasts commodity/freight movements with a four-step model — generation, distribution, mode choice, and assignment. This structure and process was found to be comparable with most modeling efforts of other states. Other states used either a three- or four-step modeling process or a variant of those processes. There were two examples found where other states were developing advanced state of the art integrated land-use transportation models. Based on the comparison between the Texas SAM and other state models, it was found that the Texas SAM is equivalent to state-of-the-practice in statewide modeling of commodities and freight.

URBAN FREIGHT/COMMODITY MODEL

The Texas SAM provides reasonable estimates of commodity and freight movements by mode on a statewide basis. It does not, however, provide sufficient detail at the urban zone level to be used directly in modeling urban commodity/freight movements as a part of the urban travel demand modeling efforts in Texas. This research developed a disaggregation model for integrating the internal urban Texas SAM commodity/freight movements into the urban zone structure. An urban commodity/freight generation model was developed to estimate the amount of commodities being shipped and received at the urban zone level. That model was developed using data from the commercial vehicle and work place surveys conducted in urban areas as part of the state travel survey program. The model was developed to be implemented with the software packages used by TxDOT in their urban travel demand models, i.e., TripCAL5, ATOM2, and TransCAD.

A methodology was also developed to integrate the Texas SAM commodity/freight model results into the urban travel demand models in the estimation of external local and external through movements. This methodology is predicated on a critical link analysis identifying the SAM movements entering and exiting the urban study area at the urban external stations and then using data from the urban external survey to distribute those movements to the urban zone structure.

An example of the application of the urban commodity/freight model was presented to demonstrate the feasibility of the model concept and the reasonableness of the subsequent results. While the results appear reasonable, it was recognized that very little data is available at the urban level to calibrate the model and verify the results. In addition, a number of assumptions were necessary to apply the model. These assumptions were necessary due to the lack of specific data and information on the movement of commodities within urban areas. This research has

identified a number of areas where travel surveys may be improved and provide necessary key data elements to improve the urban commodity/freight model. The following recommendations are made:

- Commercial vehicle surveys in urban areas should collect data on the amount of cargo being delivered and/or picked up as well as the type of cargo.
- Commercial vehicle surveys should distinguish between vehicles that carry cargo and those that are primarily used in commercial service functions.
- Workplace surveys should identify and count the number of commercial cargo transport vehicles and commercial service vehicles traveling to and from the workplace establishment on the day of the survey.
- In the pre-survey of workplace establishments, the data collected should include the number of commercial cargo transport and service vehicles available to the establishments for business purposes.
- The saturation count program for urban areas should collect vehicle classification data at all locations being counted. If this is not feasible, commercial vehicle corridors should be identified, screen lines established and vehicle classification counts conducted at those locations to provide data for calibration and validation of urban commodity/freight models.
- Commercial vehicle surveys at external stations should collect data on the cargo weight and type being transported.
- Commercial vehicle surveys at external stations should collect vehicle classification data to provide the means to estimate the number of commercial cargo transport and service vehicles.
- A macro program should be developed for use with the Texas SAM to provide the necessary critical link data for use in the urban commodity/freight model.
- The analysis of commercial vehicle and work place surveys in urban areas should include the development and documentation of commodity shipping and receiving rates by employment type and households.

To assist in the modeling of commodities/freight movements in urban areas during the time prior to the execution of the necessary travel surveys, default commodity shipping and receiving rates, non-transfer production and attraction rates, and empty vehicle rates are included in Appendix F.

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**APPENDIX A:
FREIGHT DATA SOURCES**

DATA SOURCES AND CLASSIFICATION CODES

This appendix presents a description of the various data sources and information that is frequently used for freight transportation modeling. The appendix is divided into four sections:

- the first one presents the publicly provided information,
- the second presents the privately provided sources,
- the third presents the forms of collecting data, and
- section four presents the various classification codes used in the modeling process.

Section 1: Publicly Provided Sources

1. Commodity Flow Survey (CFS) – U.S. Census Bureau

Transportation Mode – Truck, Rail, Water, Pipeline, and Air

Time Frame – The CFS is collected every five years as part of the Economic Census. The last available data is 1997, with 2002 data scheduled released in 2004.

Geographic Coverage – National

Detail Level – Data originally collected for zip code of origin and destination, but aggregated into 89 National Transportation Analysis Regions (NTARs), stratified by state and metropolitan areas.

Data Collection Purpose – The Census Bureau conducts the CFS as part of its Economic Census every five years.

Scope – The CFS provides commodity flow data by all modes used for a shipment, including

- truck,
- rail,
- water,
- pipeline, and
- air.

The establishments sampled include randomly selected representatives engaged in mining, manufacturing, wholesale, auxiliary establishments (warehouses), and some selected activities in retail and service. The 100,000 establishments completing the questionnaire in the 1997 CFS produced a total sample of over 5 million shipments. For each of these shipments, the recorded data included:

- zip code of origin and destination,
- five-digit Standard Classification of Transported Goods (SCTG) code,
- weight,

- value,
- modes of transport, and
- check box information on whether the shipment was containerized, a hazardous material, or an export.

2. Vehicle Inventory and Use Survey (VIUS) – U.S. Census Bureau

Transportation Mode – Truck

Time Frame – The U.S. Census Bureau collects the VIUS every five years as part of the Economic Census. The last available data is 1997. The 2002 Survey is currently in progress.

Geographic Coverage – National

Detail Level – According to the Census Bureau, available data contain disaggregated records for individual trucks, with masking to shield disclosure of individual vehicles or owners. The geographic detail is restricted to the state of registration.

Data Collection Purpose – VIUS provides a way to measure the physical and operational characteristics of the nation’s truck population. The data collected from the Survey are used by multiple governmental agencies, such as the Department of Transportation and Bureau of Economic Analysis, and private firms, such as tire and truck manufacturers.

Scope – The Survey includes registered private and commercial trucks, excluding vehicles owned by federal, state, or local governments; ambulances; buses; motor homes; farm tractors; unpowered trailer units; and trucks reported to have been sold, junked, or wrecked. The information collected in the Survey includes physical characteristics, such as weight, number of axles, and overall length, and operational characteristics, such as type of use, base of operation, gas mileage, annual and lifetime miles driven, commodities hauled by type, and hazardous materials carried.

3. Rail Carload Waybill Sample – Surface Transportation Board

Transportation Mode – Rail

Time Frame – Annual, with 2001 being the most recent data available.

Geographic Coverage – National: The Confidential Master File for individual states contains rail movement originating, terminating, or passing through that particular state. The Public Use File covers the entire United States.

Detail Level – The Confidential Master File contains specific rail shipment information, while the Public Use File is aggregated to shield proprietary data identifying specific railroads, rail equipment, and station locations.

Data Collection Purpose – U.S. railroads meeting minimum filing requirements report annually to the Surface Transportation Board, the federal regulating agency over the U.S. railroads.

Scope – The waybill sample identifies:

- originating and terminating freight stations,
- the names of all railroads participating in the movement,
- the point of all railroad interchanges,
- the number of cars,
- the car types,
- the movement weight,
- the commodity, and
- the freight revenue.

Each record in the waybill sample consists of over 200 fields of information.

4. Transborder Surface Freight Data – Bureau of Transportation Statistics

Transportation Mode – Truck, Rail, Pipeline, Mail, and Other

Time Frame – Monthly, with January 2003 being the latest available data.

Geographic Coverage – National

Detail Level – The database is disseminated in accordance to the U.S. Census Bureau's confidentiality requirements, which results in aggregation of the data to support this mandate.

Data Collection Purpose – The motivation of collecting transborder transportation data was to monitor freight flows with the signing of the North American Free Trade Agreement (NAFTA) in 1993. This database provides a means to monitor the changes in the flows over time, and also provides data for transportation studies such as transportation infrastructure plans.

Scope – The database provides freight flow data by commodity type and transportation mode for U.S. exports to and imports from Canada and Mexico. Additional fields of information for import data include:

- containerization code,
- U.S. state of destination,
- country of origin,
- port of entry,
- merchandise value,
- aggregate freight charges, and
- shipping weight.

Export data includes U.S. state of origin, port of entry, Canada province of clearance or Mexico destination state, aggregate freight charges, and merchandise value.

5. County Business Patterns (CBP): Department of Commerce/Bureau of Economic Analysis

Time Frame – Annual

Geographic Coverage – National

Detail Level – Data are presented at a county level.

Data Collection Purpose – The CBP provides valuable county-level economic data that allow for monitoring and trending of local, state, and national economic factors.

Scope – Publications are released on national and state levels portraying county-level data on the number of establishments, employment, and payroll. The establishments are classified according to principle activity occurring at each location.

6. Highway Performing Monitoring System

Transportation Mode – Truck and auto volumes.

Time Frame – Biannual data collection.

Geographic Coverage – National at the state level.

Detail Level – Information provided by the state DOTs includes a “truck percentage,” that is reported as an annualized value. This information is consistent with the new Traffic Monitoring Guide (TMG) that has the ability to adjust short-term truck data to represent truck AADT. Average truck payload is also reported.

Data Collection Purpose – The HPMS was developed in 1978 as a national highway transportation system database.

Scope – Provides data that reflect the extent, condition, performance, use, and operating characteristics of the Nation’s highways. It includes limited data on all public roads, more detailed data for a sample of the arterial and collector functional systems, and certain statewide summary information.

Section 2: Privately Provided Sources

1. TRANSEARCH – Reebie Associates

Transportation Mode – Truck, Rail, Water, and Air

Time Frame – Annual, with 2000 being the most recent data available.

Geographic Coverage – National

Detail Level – Customization available for county or zip code level. The Texas Statewide Analysis Model required customization for 4,600 zones.

Data Collection Purpose – The TRANSEARCH database provides O-D freight flows for the major modes of transportation in the U.S. This information is developed by formulating over 100 proprietary, commercial, and public sources of data into a single common framework.

Scope – Reebie Associates’ proprietary database provides tonnage and equipment volumes by commodity, transportation mode, and lane. International shipments between the U.S. and both Canada and Mexico are available for select modes.

2. IMPLAN Group, Inc (MIG, Inc.).

Information - Employment, income, value added, household and government consumption.

Time frame – 2001 data.

Geographic Coverage – National, data are available for individual state, county and custom Zip Code level. State data packages include the U.S. file, the state file, and all county files in that state.

Detail Level – Data files include information for a set of highly disaggregated industries, generally three- or four-digit SIC code breakdown.

Scope – IMPLAN® Data Files combined with the IMPLAN Professional® software system allow the user to develop local level input-output models that can estimate economic impacts.

Section 3: Forms of Collecting Data

1. Vehicle Classification Counts

Vehicle classification studies stratify vehicle counts according to vehicle characteristics, such as passenger car, commercial truck, or bus, for the particular study location. They provide base data for transportation models along with data for model calibration and validation.

2. Shipper Surveys

Shipper surveys provide direct information related to trip generation rates, shipment origin-destinations, and shipping decision factors. In acquiring decision factors, of particular interest is the understanding of mode choice, route choice, and delivery scheduling.

3. Trip Diaries

Trip diaries involve a driver logging trip activities throughout a designated time period. The log documents information such as shipment characteristics, origin and destination locations, time of trips, distance of trips, and land use at trip ends.

4. Terminal and Transportation Facility Surveys

Developing an inventory of the facilities around an urban area provides significant data on the major generators of traffic traversing the transportation network. Facility surveys are multi-modal in nature capturing the major highway (truck), rail, air, pipeline, and marine terminals. The following lists the urban terminals and transportation facilities desired to inventory:

- processing and manufacturing facilities;
- warehouse and distribution centers;
- truck terminals, both truckload and less-than-truckload;
- truck-rail intermodal facilities; and
- marine and port terminals.

Types of information desired for each facility include facility size, types of goods handled, connecting modes, and hours of operation.

Section 4: Classification Codes

1. Standard Industrial Codes (SIC)

Standard Industrial Classification (SIC) system has served as the structure for the collection, aggregation, presentation, and analysis of the U.S. economy. An industry consists of a group of establishments primarily engaged in producing or handling the same product or group of products or in rendering the same services. Table A-1 presents the two-digit SIC classification.

Table A-1. SIC Classifications.

Code	Industry
11	Agriculture, Forestry, Fishing, and Hunting
21	Mining
22	Utilities
23	Construction
31-33	Manufacturing
42	Wholesale Trade
44-45	Retail Trade
48-49	Transportation and Warehousing
51	Information
52	Finance and Insurance
53	Real Estate and Rental and Leasing
54	Professional, Scientific and Technical Services
55	Management of Companies and Enterprises
56	Administrative and Support and Waste Management and Remediation Services
61	Educational Services
62	Health Care and Social Assistance
71	Arts, Entertainment and Recreation
72	Accommodation and Food Services
81	Other Services (except Public Administration)
92	Public Administration

2. Standard Transportation Commodity Codes

STCC code is a seven-digit numeric code representing 38 commodity groupings. Assignment of an STCC Code is associated by a commodity description developed to conform with exact descriptions in freight transportation classifications of rail and motor carriers. Table A-2 presents the STCC classifications.

Table A-2. STCC Classifications.

STCC Code	Commodity Description
1	Farm products products
8	Forest products
9	Fresh fish
10	Metallic ores
11	Coal
13	Crude petroleum, natural gas or Gasoline
14	Nonmetallic ores, minerals, excluding fuels
19	Ordnance or accessories
20	Food and kindred products
21	Tobacco products, excluding insecticides
22	Textile mill products
23	Apparel or other finished textile products or knit apparel
24	Lumber or wood products, excluding furniture
25	Furniture or fixtures
26	Pulp, paper, or allied products
27	Printed matter hazardous substances
28	Chemicals or allied products
29	Petroleum or coal products
30	Rubber or miscellaneous plastics
31	Leather or leather products
32	Clay, concrete, glass, or stone products
33	Primary metal products
34	Fabricated metal products
35	Machinery, excluding electrical
36	Electrical machinery, equipment, or supplies
37	Transportation equipment
38	Instruments, photographic goods, optical goods, watches, or clocks
39	Miscellaneous products of manufacturing
40	Waste or scrap materials not identified by producing industry
41	Miscellaneous freight shipments
42	Containers, carriers or devices, shipping, returned empty
48	Waste hazardous materials or waste
--	Commodity unknown

**APPENDIX B:
COMMODITY DISAGGREGATION PROGRAM**

COMMODITY DISAGGREGATION PROGRAM

This program disaggregates commodity flows using total employment by zone within county. The program outputs commodity shipping and receiving by zone in the same model format as the TRIPCAL5 program used by TxDOT.

Program Function

The user must define the names and locations of three input data sets and six output data sets to start the COM_DISAG program. A heading field and a commodity flow multiplication factor are optional.

Input Data Sets

The input data sets are:

- 1) DA1 data records for all zones.
- 2) Equivalency classification (EC) records that equate the Federal Information Processing Standards (FIPS) county codes to all zones in the urban area and optional FIPS COUNTY records defining the county names associated with each FIPS code.
- 3) SAM Model Commodity Flow data

The formats of the EC records, the FIPS COUNTY records, and the Commodity Flow data are defined in this appendix. The DA1 records are defined in TRIPCAL5 documentation (74).

Output Data Sets

The six output files are a listing file and five commodity flow shipping and receiving estimates by zone. The five files with commodity estimates are referred to as generation (GEN) files. The file extension for the listing data set is set to LST. The file extension for the commodity estimates (e.g., GEN) is ASC for ASCII, TXT for text, or user definable. The following describes the process for executing the program.

- 1) The listing output data set name and directory structure must be defined by the user. The file extension name will be set to LST.
- 2) The first generation (GEN) data set name will automatically set the other 4 generation names if it ends in the character 1 (e.g., GEN1). If the first generation file name ends in 1 before the file extension, the second generation name will be set to the first generation name with the final character changed from 1 to 2. For example, if the first generation file is set to GEN1, the second will be automatically named GEN2. The third, fourth, and fifth files are automatically named in the same manner (i.e., GEN3, GEN4, and GEN5).
- 3) The second, third, fourth, and fifth generation file names can be overridden but must be entered by the user.

Optional Fields

There are two optional fields which are:

- 1) The header field. This field can be blank or can be set to any text.
- 2) Commodity flow multiplier. This field defaults to 1. It can be set to any value larger than zero. For example, if the user wants quarter ton units then this field should be set to 4.

Output Data Sets

The output data sets are:

- 1) Listing file – contains error messages, totals, and data set names.
- 2) First generation file (e.g., GEN1) – AGRICULTURE , RAW MATERIALS shipping and receiving estimates.
- 3) Second generation file (e.g., GEN2) – FOOD, TEXTILES shipping and receiving estimates.
- 4) Third generation file (e.g., GEN3) – WOOD, BUILDING MATERIALS shipping and receiving estimates.
- 5) Fourth generation file (e.g., GEN4) – MACHINERY, MISCELLANIOUS shipping and receiving estimates.
- 6) Fifth generation file (e.g., GEN5) – SECONDARY, HAZARDOUS MATERIALS shipping and receiving estimates.

Operation

The dialog box section of the program is run to define the three input data sets, the six output data set names, the Header field (optional), and the Flow multiplier (optional). The nine data set name fields are checked by the program to see that they are input. The flow multiplier is checked to see that it is greater than zero if a value is input.

The DA1 records are read. The EC records are read. The optional FIPS COUNTY records are read when the EC records are read. The commodity flow records are read.

The total employment by zone is calculated from Basic Employment, Service Employment, and Retail Employment.

The total shipping and receiving tons for nine commodity types are summed from the flow data. The order of the commodity estimates expected by the program are:

- origin zone,
- destination zone,
- agriculture,
- raw materials,
- food,

- textiles,
- wood,
- chemical/petroleum,
- building materials,
- machinery,
- miscellaneous,
- secondary, and
- hazardous materials.

The chemical/petroleum tons are summed with raw materials. Scale factors by county are then calculated to scale the total employment to shipping and receiving tons by commodity and county.

The largest values by zone are determined for each of the eight commodities by shipping and receiving and an output format is determined to fit the 12 characters of the field.

The shipping and receiving values are calculated by zone and output to the five generation files.

DA1 Input Data

Format - (A3,I5,9F7.0)

<u>Columns</u>	<u>FMT</u>	<u>Contents</u>
1-3	A3	“DA1”
4-8	I5	Zone number
9-15	F7.0	Zone size in acres
16-22	F7.0	Total zone population
23-29	F7.0	Total households in zone
30-36	F7.0	Average household size for zone ¹
37-43	F7.0	Median household income in zone
44-50	F7.0	Zone total employment
51-57	F7.0	Zone total basic employment
58-64	F7.0	Zone total retail employment
65-71	F7.0	Zone total service employment

¹ If left blank, program will compute.

SAM Model Commodity Flows Input Data

Comma delimited Data Fields

Field Number	Data in Field
1	Origin county FIPS code
2	Destination county FIPS code
3	Agriculture tons moving from origin to destination
4	Raw materials tons moving from origin to destination
5	Food tons moving from origin to destination
6	Textiles tons moving from origin to destination
7	Wood tons moving from origin to destination
8	Chemical / petroleum tons moving from origin to destination
9	Building materials tons moving from origin to destination
10	Machinery tons moving from origin to destination
11	Miscellaneous tons moving from origin to destination
12	Secondary tons moving from origin to destination
13	Hazardous materials tons moving from origin to destination

FIPS NAME Input Records

Column	Format	Description/Contents	Justification
1-9	A9	Card type "FIPS NAME"	Left
10		Blank	
11-16	I6	FIPS code for state and county	Right
17		Blank	
18-47	A30	County name	Left

EC Input Records

Column	Format	Description/Contents	Justification
1-2	A2	Card Type "EC"	Left
3-10	I8	FIPS code	Right
11-15	I5	Zone or zone range field 1	Right
16-20	I5	Zone or zone range field 2	Right
21-25	I5	Zone or zone range field 3	Right
26-30	I5	Zone or zone range field 4	Right
31-35	I5	Zone or zone range field 5	Right
36-40	I5	Zone or zone range field 6	Right
41-45	I5	Zone or zone range field 7	Right
46-50	I5	Zone or zone range field 8	Right
51-55	I5	Zone or zone range field 9	Right
56-60	I5	Zone or zone range field 10	Right
61-65	I5	Zone or zone range field 11	Right
66-70	I5	Zone or zone range field 12	Right
71-75	I5	Zone or zone range field 13	Right
76-80	I5	Zone or zone range field 14	Right
86-90	I5	Zone or zone range field 15	Right

The EC records equate urban zones to FIPS counties.

Generation Records

Column	Format	Description/Contents	Justification
1-10	A10	Card Type "GENERATION"	Left
11-15	I5	Zone number	Right
16-27	F12.?	Shipping Tons for commodity 1	Right
28-39	F12.?	Receiving Tons for commodity 1	Right
41-52	F12.?	Shipping Tons for commodity 2	Right
53-64	F12.?	Receiving Tons for commodity 2	Right
66-100	A35	Commodity 1 description, Commodity 2 description	Left

Same format is used for each generation file.

GISDK Code

```
MACRO "COM_DISAG"
Global ptr_d,dal_name_d,sgz_name,com_disag_dal_name
RunDbox("com_23_BOX1")
endmacro

Macro "com_disag"
RunMacro("COM_DISAG")
endmacro

DBOX "com_23_BOX1" title: "Disaggregate Commodity Movement Data"
init do
    global com_disag_dal_name, com_disag_EC_name, com_disag_list_name,
com_disag_header
    global Fill_Year_d,TAZfld_d, fldnames_d, com_disag_pcr_name,
com_disag_flow_name
    global com_disag_gen1, com_disag_gen2, com_disag_gen3,
com_disag_gen4, com_disag_gen5, com_disag_qt
    com_disag_dal_name = "nul"
    com_disag_EC_name = "nul"
    com_disag_flow_name = "nul"
    com_disag_list_name = "nul"
    com_disag_pcr_name = "nul"
    com_disag_gen1 = "nul"
    com_disag_gen2 = "nul"
    com_disag_gen3 = "nul"
    com_disag_gen4 = "nul"
    com_disag_gen5 = "nul"
    com_disag_header = " "
    com_disag_qt = 1
    Fill_Year_d = 9999
    lyrs = GetLayerNames()
enditem

//
// ++++++
// DA1 name
// ++++++
Text "DA1 data file" 6,1
Checkbox 2.5,2.5 variable:chkdal
do if chkdal=1 then do
    com_disag_dal_name =
ChooseFile({"Text","*.txt"},{"Ascii","*.asc"},{"All file types","*.*"}),
"Choose DA1 File",Null)
end
if chkdal=0 then do
    com_disag_dal_name="nul"
end
enditem
text "fcnamin" 6,2.5,60
```

```

        Framed
        variable: com_disag_dal_name

//
// ++++++
// EC name
// ++++++
//
    Text "EC County Equivalence & FIPS Name file" 6,4
    Checkbox 2.5,5.5 variable:chksgz
        do if chksgz=1 then do
            com_disag_EC_name =
ChooseFile({"Text","*.txt"},{"Ascii","*.asc"},{"All file types","*.*"}},
"Choose a EC File",Null)
        end
        if chksgz=0 then do
            com_disag_EC_name="nul"
        end
    enditem
    text "fcnaminat" 6,5.5,60
        Framed
        variable: com_disag_EC_name

//
// ++++++
// Commodity Flow name
// ++++++
    Text "Input Commodity Flow Data " 6,7
    Checkbox 2.5,8.5 variable:flow_in
        do if flow_in=1 then do
            com_disag_flow_name =
ChooseFile({"Text","*.txt"},{"Ascii","*.asc"},{"All file types","*.*"}},
"Chose a Flow Data file",Null)
        end
        if flow_in=0 then do
            com_disag_flow_name="nul"
        end
    enditem
    text "fcnaminat" 6,8.5,60
        Framed
        variable: com_disag_flow_name

//
// ++++++
// List name
// ++++++
    Text "Output Listing File " 6,10
    Checkbox 2.5,11.5 variable:chklst
        do if chklst=1 then do
            com_disag_list_name = ChooseFileName({"List File", "*.lst"}},
"Save the List File as",Null)
        end
        if chklst=0 then do

```

```

        com_disag_list_namee="nul"
    end
enditem
text "fcnaminat" 6,11.5,60
    Framed
    variable: com_disag_list_name

//
// ++++++
// GEN1 name
// ++++++
    Text "Output GEN1 Data " 6,13
    Checkbox 2.5,14.5 variable:daout
        do if daout=1 then do
            com_disag_gen1 =
ChooseFileName({"Text","*.txt"},{"Ascii","*.asc"},{"All file types","*.*"}},
"Save the GEN 1 Data as",Null)
            ngen1 = StringLength(com_disag_gen1)
            lastc = Substring(com_disag_gen1,ngen1-4,1)
            if lastc = "1" then do
                genbase = Substring(com_disag_gen1,1,ngen1-5)
                if com_disag_gen2 = "nul" then DO
                    com_disag_gen2 = genbase+"2.TXT"
//                    SetCheck("ck2 bx", "Checked")
                end
                if com_disag_gen3 = "nul" then do
                    com_disag_gen3 = genbase+"3.TXT"
//                    SetCheck("ck3", "Checked")
                end
                if com_disag_gen4 = "nul" then com_disag_gen4 =
genbase+"4.TXT"
                if com_disag_gen5 = "nul" then com_disag_gen5 =
genbase+"5.TXT"
                    dsout2 = 1
                end
            end
            if daout=0 then do
                com_disag_gen1="nul"
            end
        enditem
text "fcnaminat" 6,14.5,60
    Framed
    variable: com_disag_gen1

//
// ++++++
// GEN2 name
// ++++++
    Text "Output GEN2 Data " 6,16
    Checkbox "ck2 bx" 2.5,17.5 variable:daout2
        do if daout2=1 then do
            com_disag_gen2 =
ChooseFileName({"Text","*.txt"},{"Ascii","*.asc"},{"All file types","*.*"}},
"Save the GEN 2 Data as",Null)
            end
            if daout2=0 then do

```

```

        com_disag_gen2="nul"
    end
enditem
text "fcnaminat" 6,17.5,60
    Framed
    variable: com_disag_gen2

//
// ++++++
// GEN3 name
// ++++++
    Text "Output GEN3 Data " 6,19
    Checkbox "ck3" 2.5,20.5 variable:daout3
    do if daout3=1 then do
        com_disag_gen3 =
ChooseFileName({"Text","*.txt"},{"Ascii","*.asc"},{"All file types","*.*"}},
"Save the GEN 3 Data as",Null)
    end
    if daout3=0 then do
        com_disag_gen3="nul"
    end
enditem
text "fcnaminat" 6,20.5,60
    Framed
    variable: com_disag_gen3

//
// ++++++
// GEN4 name
// ++++++
    Text "Output GEN4 Data " 6,22
    Checkbox 2.5,23.5 variable:daout4
    do if daout4=1 then do
        com_disag_gen4 =
ChooseFileName({"Text","*.txt"},{"Ascii","*.asc"},{"All file types","*.*"}},
"Save the GEN 4 Data as",Null)
    end
    if daout4=0 then do
        com_disag_gen4="nul"
    end
enditem
text "fcnaminat" 6,23.5,60
    Framed
    variable: com_disag_gen4

//
// ++++++
// GEN5 name
// ++++++
    Text "Output GEN5 Data " 6,25
    Checkbox 2.5,26.5 variable:daout5
    do if daout5=1 then do
        com_disag_gen5 =
ChooseFileName({"Text","*.txt"},{"Ascii","*.asc"},{"All file types","*.*"}},
"Save the GEN 5 Data as",Null)
    end
end

```

```

        if daout5=0 then do
            com_disag_gen5="nul"
        end
    enditem
text "fcnaminat" 6,26.5,60
    Framed
    variable: com_disag_gen5

Text "Heading" 6,28
Edit text "header_B" 6,29.5,60
    variable: com_disag_header

Edit Real 12,31.5
    Prompt: " Scale Factor"
    Variable: com_disag_qt

button "Cancel" 29,33.5,10 do
    Return()
enditem

button "OK" 32,35.5,4 do

    if com_disag_da1_name = "nul" or Len(com_disag_da1_name) < 3
then do
        ShowMessage(" Choose a DA1 data file name.")
        goto skipOK
    end

    if com_disag_EC_name = "nul" or Len(com_disag_EC_name) < 3
then do
        ShowMessage(" Choose a EC data file name.")
        goto skipOK
    end

    if com_disag_list_name = "nul" or Len(com_disag_list_name) <
3 then do
        ShowMessage(" Choose a Listing file name.")
        goto skipOK
    end

    if com_disag_flow_name = "nul" or Len(com_disag_flow_name) <
3 then do
        ShowMessage(" Choose a Flow file name.")
        goto skipOK
    end

    if com_disag_gen1 = "nul" or Len(com_disag_gen1) < 3 then do
        ShowMessage(" Choose a GEN1 Data File name.")
        goto skipOK
    end

    if com_disag_gen2 = "nul" or Len(com_disag_gen2) < 3 then do
        ShowMessage(" Choose a GEN2 Data File name.")
        goto skipOK
    end
end
end

```

```

        if com_disag_gen3 = "nul" or Len(com_disag_gen3) < 3 then do
            ShowMessage(" Choose a GEN3 Data File name.")
            goto skipOK
        end

        if com_disag_gen4 = "nul" or Len(com_disag_gen4) < 3 then do
            ShowMessage(" Choose a GEN4 Data File name.")
            goto skipOK
        end

        if com_disag_gen5 = "nul" or Len(com_disag_gen5) < 3 then do
            ShowMessage(" Choose a GEN5 Data File name.")
            goto skipOK
        end

        if com_disag_qt <= 0 then do
            ShowMessage(" Scale factor must be greater than zero.")
            goto skipOK
        end

        RunMacro("com_23")
        Return()

skipOK:
        enditem

    enddbox

Macro "com_23"
    HideDbox("com_23_BOX1")
        nbar = 0
        mb = 0
        ptral_r=OpenFile(com_disag_dal_name,"r") // check length of
first record
        mxz = 0

// Trap some other Transcad errors
    on Error goto error_end
    on NotFound goto error_end
    on Escape goto error_end
    on NonUnique goto error_end
    on Missing goto error_end
    on DivideByZero goto error_end
    on EndOfFile goto error_end
//
    on Locked goto error_end
    on LanguageError goto error_end

// build commodity 11 types to 10 types TOE
    Dim ceq[11]
    for j=1 to 5 do
        ceq[j] = j
    end

```

```

ceq[6] = 2
for j=7 to 11 do
  ceq[j] = j - 1
end

ptral_r=OpenFile(com_disag_da1_name,"r") // check length of first
record
mxzn = -1
nrr = 0
on EndOfFile goto EndDA1
for j=1 to 999999 do
  recda1 = ReadLine(ptral_r)
  if Substring(recda1,1,3) = "DA1" then do
    jz = S2i(Substring(recda1,4,5))
    mxzn = Max(mxzn,jz)
  end
end
EndDA1:
mxrec = j - 1
// ShowMessage("Number of records = "+R2s(mxrec))
// ShowMessage("Maximum zone number = "+R2s(mxzn))
CloseFile(ptral_r)

ptral_r=OpenFile(com_disag_da1_name,"r") // Read DA1 data

mxzn = R2i(mxzn)
Dim hh[mxzn],basic[mxzn],retail[mxzn],service[mxzn],totemp[mxzn]

on EndOfFile goto EndDA1b

  EnableProgressBar("com_23",10)
  CreateProgressBar("Read DA1 Records", "True")
  nbar = nbar + 1

for j=1 to mxrec do
  recda1 = ReadLine(ptral_r)
  perc=r2i((j/mxzn)*100)
  stat=UpdateProgressBar("Read DA1 Records",perc)

  jz = S2i(Substring(recda1,4,5))
  if jz > 0 and jz <= mxzn then do
    hh[jz] = S2r(Substring(recda1,23,7))
    basic[jz] = S2r(Substring(recda1,51,7))
    retail[jz] = S2r(Substring(recda1,58,7))
    service[jz] = S2r(Substring(recda1,65,7))
    totemp[jz] = basic[jz] + retail[jz] + service[jz]
  end
end
EndDA1b:
mxrec = j - 1
CloseFile(ptral_r)

// Sum totemp by county for scaling control totals

// read the EC data and build the AC zone to County table of Equals array
Dim ac[mxzn]

```

```

for j=1 to mxzn do
  ac[j] = -1
end

ptrec_r=OpenFile(com_disag_EC_name,"r") // Read EA data
on EndOfFile goto EndEC
Dim atc[16]
for j=1 to 16 do
  atc[j] = 0
end

CreateProgressBar("Read EA Records", "True")
nbar = nbar + 1
nec = 0
Dim zadd[1]
zadd[1] = ""
nzadd = 0

for j=1 to 999999 do
  perc=r2i((nec/mxzn)*100)
  stat=UpdateProgressBar("Read EC Records",perc)
  recea = ReadLine(ptrec_r)

  if Substring(recea,1,9) = "FIPS NAME" then do
    zc = substring(recea,11,30)
    cfips = substring(recea,11,6)
    nfips = S2r(cfips)
    bfips = Lpad(Format(nfips,"*0"),6)
// Convert blanks to zeroes
    bfips = Substitute(bfips," ","0",)
    zc = bfips + " " + Trim(Substring(recea,18,30))
    zadd = zadd + {zc}
    nzadd = nzadd + 1
  end

  if Substring(recea,1,2) = "EC" then do
    atc[1] = S2i(Substring(recea,3,8))
    c1 = 11
    for k=2 to 16 do
      atc[k] = S2i(Substring(recea,c1,5))
      c1 = c1 + 5
    end

    jskip = 0
    for k=2 to 16 do
      if(jskip = 1) then do
        jskip = 0
        goto end_for_k
      end

      if(atc[k] = 0) then goto return_k
      if(k <= 15) then do

```



```

        if(atc[k] > 0 and atc[k+1] < 1) then do
            if(atc[k] < abs(atc[k+1])) then do
                ls = atc[k]
                lex = abs(atc[k+1])
                for m=ls to lex do
                    ac[m] = atc[1]
                    nec = nec + 1
                end
                jskip = 1
                goto end_for_k
            end
        end
    end

    if(atc[k] > 0) then do
        m = atc[k]
        ac[m] = atc[1]
        nec = nec + 1
        jskip = 0
        goto end_for_k
    end
end_for_k:
    end
return_k:
    perc=r2i((nec/mxzn)*100)
    stat=UpdateProgressBar("Read EC Records",perc)

//          ShowArray(at)

    end
end

EndEC:

Dim fips[54999],rfips[54999]
for j=1 to 54999 do
    fips[j] = -1
    rfips[j] = -1
end

// Assign fips codes to sequential county numbers
sf = 0
for j=1 to mxzn do
    m = ac[j]
    if fips[m] = -1 then do
        sf = sf + 1
        fips[m] = sf
        rfips[sf] = m
    end
end

ptr_lst = OpenFile(com_disag_list_name,"w")
WriteLine(ptr_lst,com_disag_header)
WriteLine(ptr_lst," ")

```

```

        WriteLine(ptr_lst," DA1 Input File      = "+com_disag_dal_name)
        WriteLine(ptr_lst," EC Input File      = "+com_disag_EC_name)
        WriteLine(ptr_lst," ")
        WriteLine(ptr_lst," Commodity Flow Input ile      =
"+com_disag_flow_name)
        WriteLine(ptr_lst," GEN1 Output file = "+com_disag_gen1)
        WriteLine(ptr_lst," Generation scale factor = "+R2s(com_disag_gt))

        nec = j-1
        mxaz = -1
        nt = 0
// LOOK FOR MISSING ZONES IN THE DA1 DATA
        nms = 0
        for j=1 to mxzn do
            if(hh[j] < 0.0) then nms = nms + 1
        end
        if(nms > 0) then do
            nrr = nrr + 1
            WriteLine(ptr_lst," Error missing dal data for "+R2s(cme)+" zones")
        end

        for j=1 to mxzn do
            if(ac[j] > 0) then do
                mxaz = j
                nt = nt + 1
            end
        end
        WriteLine(ptr_lst," Maximum Areatype zone = "+R2S(mxaz))
        WriteLine(ptr_lst,"      number of AT zones = "+R2S(nt))
        WriteLine(ptr_lst,"      EC records = "+R2S(nec))

//
//      WRITE(6,219) (J,(AT(L),L=J,MIN(J+24,MXAZ)),J=1,MXAZ,25)
// 219 FORMAT(' AT(',I4,') =',1X,25I3)
//      for j=1 to mxaz step 25 do
//          ln = " ac["+Lpad(R2S(j),4)+"] ="
//          for k=j to Min(j+24,mxaz) do
//              ln = ln + " "+R2s(ac[k])
//          end
//          WriteLine(ptr_lst,ln)
//      end

// Report missing area type zones
        if(mxaz <> nt) or (mxaz <> mxzn) then do
            lines = 0
//      SUBROUTINE OUTEQ(mxzn,-1,at)
            DIM z[999]
            for j=1 to 999 do
                z[j] = -1
            end
//C LOOK FOR SECTORS 1 TO M
            lns = 0
            is = -1
// 100 format('1''0''0table e2',t50,'Zones missing in EC records'/1x)
            g = 0
//c beginning of loop to find a zone equated to sector is

```

```

        j = 0
outeq03:
        j = j + 1
        if(j > mxzn) then goto outeq04
        if(ac[j] <> is) then goto outeq03
//c search for a range
        j2 = j + 1
        for k = j2 to mxzn do
            if(ac[k] <> is) then goto outeq06
outeq05:
        end
        k = mxzn + 1
outeq06:
        if(k-1 > j) then goto outeq61
//c insert single zone
        if(g <= 6) then goto outeq08
        lns = lns + 1
        if(Mod(lns,50) = 1) then WriteLine(ptr_lst," Zones Missing in EC
Records")
        ln = " "
        for i=1 to g do
            ln = ln + Lpad(Format(z[i],"*0"),7)
        end
        WriteLine(ptr_lst,ln)
        g = 0
outeq08:
        z[g+1] = j
        g = g + 1
        j = j + 1
        goto outeq03
//c insert range of zones
outeq61:
        if(g <= 5) then goto outeq07
        lns = lns + 1
        if(Mod(lns,50) = 1) then WriteLine(ptr_lst," Zones Missing in EC
Records")
        ln = " "
        for i=1 to g do
            ln = ln + Lpad(Format(z[i],"*0"),7)
        end
        WriteLine(ptr_lst,ln)
        g = 0
outeq07:
        z[g+1] = j
        z[g+2] = -(k - 1)
//c check if range of 2, if so make into 2 zones
        if(z[g+2]+1 = -z[g+1]) then z[g+2] = -z[g+2]
        g = g + 2
        j = k
        goto outeq03
outeq04:
        if(g = 0) then goto outeq02
        lns = lns + 1
        if(Mod(lns,50) = 1) then WriteLine(ptr_lst," Zones Missing in EC
Records")
        ln = " "
        for i=1 to g do

```

```

        ln = ln + Lpad(Format(z[i],"*0"),7)
    end
    g = 0
    WriteLine(ptr_lst,ln)
outeq02:
    if g > 0 then do
        if(Mod(lns,50) = 1) then WriteLine(ptr_lst," Zones Missing in EC
Records")
            ln = " "
            for i=1 to g do
                ln = ln + Lpad(Format(z[i],"*0"),7)
            end
            WriteLine(ptr_lst,ln)
            g = 0
        end
    end

    if(mxaz <> nt) then do
        nrr = nrr + 1
        mis_ea = mxaz - nt
        WriteLine(ptr_lst," Error Missing "+R2s(mis_ea)+
            " zones in the area type table of equals")
    end
    if(mxaz <> mxzn) then do
        nrr = nrr + 1
        WriteLine(ptr_lst," Error DA1 number of zones = "+Lpad(R2s(mxzn),6)
            +" and EC last zone = "+Lpad(R2s(mxaz),6)+" are different")
    end
    if(nrr > 0) then do
        WriteLine(ptr_lst," Quitting for errors in DA1 and EC data")
        goto normal_end
    end

    for j=1 to mxzn do
        tothh = tothh + hh[j]
        lat = ac[j]
        if(lat < 1 or lat > 54999) then do
            nrr = nrr + 1
            WriteLine(ptr_lst," error County Number for zone "+Lpad(R2s(j),6)+
                " is "+Lpad(R2s(lat),3))

            goto end_do2_j
        end
    end
end_do2_j:
end

// Dimension SAM Model Data Sums of PxA Flag
Dim zce[9999], cx[54999], cxs[54999]
for j=1 to 9999 do
    zce[j] = -1
end

for j=1 to 54999 do

```

```

        cx[j] = 0
        cxs[j] = -1
    end

// sum number of county zones in array cx from array ac
    for j=1 to mxzn do
        c = R2i(ac[j])
        if c > 0 and c < 55000 then do
            cx[c] = cx[c] + 1
        end
    end

// assign sequential numbers to the county numbers present for indexing into
the cm array
    xcm = 0
    for j=1 to 54999 do
        if cx[j] > 0 then do
            xcm = xcm + 1
            cxs[j] = xcm
        end
    end
    xcm = R2i(xcm)

// xcm = the number of counties
    Dim cm[xcm]
    Dim org[xcm],dst[xcm]
    for j=1 to xcm do
        org[j] = 0
        dst[j] = 0
        Dim cmy[xcm]
        cm[j] = cmy
        for k=1 to xcm do
            Dim cmz[10]
            cm[j][k] = cmz
            for m=1 to 10 do
                cm[j][k][m] = 0
            end
        end
    end

// Dimension control totals by county Shipping    s and Attraction arrays and
initialize to zero
    Dim cp[xcm], ca[xcm],cemp[xcm], pscale[xcm], ascale[xcm]
    for j=1 to xcm do
        cemp[j] = 0
        Dim p10[10], a10[10], ps10[10], as10[10]
        cp[j] = p10
        ca[j] = a10
        pscale[j] = ps10
        ascale[j] = as10
        for k=1 to 10 do
            cp[j][k] = 0
            ca[j][k] = 0
            pscale[j][k] = 0
            ascale[j][k] = 0
        end
    end

```

```

// cm[j][k][11] is the PxA flag

// Open the comma delimited commodity flow estimates and sum in the cm array
ptr_flow = OpenFile(com_disag_flow_name,"r")
on EndOfFile goto Endflow
Dim cs[17]
for mz=1 to 17 do
  cs[mz] = -1
end

for j=1 to 9999999 do
  recflow = ReadLine(ptr_flow)

  for mz=1 to 17 do
    cs[mz] = -1
  end

  nc = StringLength(recflow)
  jc = 0
  jcp = 1
  rcf = recflow
  for k=1 to 16 do
    n = StringLength(rcf)
    if n = 0 then goto more12
    cml = Position(rcf,",")
    if cml > 0 then do
      jc = jc + 1
      lng = cml - 1
      cnum = Substring(rcf,1,lng)
      rcf = Substring(rcf,cml+1,)
      cs[jc] = cnum
    end
    if cml <= 0 then do
      jc = jc + 1
      cs[jc] = rcf
      rcf = ""
    end

    //      cs[jc+1] = SubString(rcf,jcp,lng)
    //      if lng <= 0 then cs[jc+1] = "0."
    //      cs[jc+1] = SubString(recflow,jcp,lng)

more12:

  end

  if jc >= 17 then do
    nrr = nrr + 1
    WriteLine(ptr_lst,"More than 17 items in line "+R2s(k))
  end
  if jc < 14 then do
    nrr = nrr + 1
    WriteLine(ptr_lst,R2s(jc)+" items in line "+R2s(k))
  end
end
// sum the Flow data

```

```

    jorg = S2i(cs[1])
    forg = fips[jorg]
    jdst = S2i(cs[2])
    kdst = fips[jdst]
    if forg = -1 then do
        nrr = nrr + 1
        WriteLine(ptr_lst," Error FIPS county code "+cs[1]+" not in
Equivalence table")
    end
    if kdst = -1 then do
        nrr = nrr + 1
        WriteLine(ptr_lst," Error FIPS county code "+cs[2]+" not in
Equivalence table")
    end
    if forg > 0 and kdst > 0 then do
        for k=1 to 11 do
            keq = R2i(ceq[k]) // array ceq sums Chem / Petr into Raw
materials
            cm[forg][kdst][keq] = cm[forg][kdst][keq] + S2r(cs[k+2])
// sum control total productions and attractions by county
            cp[forg][keq] = cp[forg][keq] + S2r(cs[k+2])
            ca[kdst][keq] = ca[kdst][keq] + S2r(cs[k+2])
        end
    end
end
end

Endflow:

// sum total county employment

for jz=1 to mxzn do
    jfps = ac[jz]
    jc = fips[jfps]
    if jc < 1 then do
        nrr = nrr + 1
        WriteLine(ptr_lst," Error Missing County TOE for zone "+R2s(jz))
    end
    if jc > 0 then cemp[jc] = cemp[jc] + totemp[jz]
end

// calculate scale factors for P x A for all counties and 10 purposes
qt = com_disag_qt
for jc=1 to xcm do
    for k=1 to 10 do
        if cemp[jc] > 0 then do
            pscale[jc][k] = qt*cp[jc][k]/cemp[jc]
            ascale[jc][k] = qt*ca[jc][k]/cemp[jc]
        end
    end
end
end

// Data for FIPS codes and county names for Arkansas, Louisiana, Oklahoma,
New Mexico, and Texas

```

```

z1 = {"022001 Acadia LA","022003 Allen LA","022005 Ascension LA","022007
Assumption LA",
      "022009 Avoyelles LA","022011 Beauregard LA","022013 Bienville
LA","022015 Bossier LA",
      "022017 Caddo LA","022019 Calcasieu LA","022021 Caldwell LA","022023
Cameron LA",
      "022025 Catahoula LA","022027 Claiborne LA","022029 Concordia
LA","022031 De soto LA",
      "022033 East Baton Rouge LA","022035 East Carroll LA","022037 East
Feliciana LA",
      "022039 Evangeline LA","022041 Franklin LA","022043 Grant LA","022045
Iberia LA",
      "022047 Iberville LA","022049 Jackson LA","022051 Jefferson
LA","022053 Jefferson Davis LA",
      "022055 Lafayette LA","022057 Lafourche LA","022059 La salle
LA","022061 Lincoln LA",
      "022063 Livingston LA","022065 Madison LA","022067 Morehouse
LA","022069 Natchitoches LA",
      "022071 Orleans LA","022073 Ouachita LA","022075 Plaquemines
LA","022077 Pointe Coupee LA"}

z2 = {"022079 Rapides LA","022081 Red River LA","022083 Richland LA","022085
Sabine LA",
      "022087 St Bernard LA","022089 St Charles LA","022091 St Helena
LA","022093 St James LA",
      "022095 St John the Baptist LA","022097 St Landry LA","022099 St
Martin LA","022101 St Mary LA",
      "022103 St Tammany LA","022105 Tangipahoa LA","022107 Tensas
LA","022109 Terrebonne LA",
      "022111 Union LA","022113 Vermilion LA","022115 Vernon LA","022117
Washington LA",
      "022119 Webster LA","022121 West Baton rouge LA","022123 West Carroll
LA","022125 West Feliciana LA",
      "022127 Winn LA","035001 Bernalillo NM","035003 Catron NM","035005
Chaves NM",
      "035006 Cibola NM","035007 Colfax NM","035009 Curry NM","035011 De
Baca NM",
      "035013 Dona Ana NM","035015 Eddy NM","035017 Grant NM","035019
Guadalupe NM",
      "035021 Harding NM","035023 Hidalgo NM","035025 Lea NM","035027
Lincoln NM"}

z3 = {"035028 Los Alamos NM","035029 Luna NM","035031 McKinley NM","035033
Mora NM",
      "035035 Otero NM","035037 Quay NM","035039 Rio Arriba NM","035041
Roosevelt NM",
      "035043 Sandoval NM","035045 San Juan NM","035047 San Miguel
NM","035049 Santa Fe NM",
      "035051 Sierra NM","035053 Socorro NM","035055 Taos NM","035057
Torrance NM","035059 Union NM",
      "035061 Valencia NM","040001 Adair OK","040003 Alfalfa OK","040005
Atoka OK",
      "040007 Beaver OK","040009 Beckham OK","040011 Blaine OK","040013
Bryan OK",
      "040015 Caddo OK","040017 Canadian OK","040019 Carter OK","040021
Cherokee OK",

```


"040023 Choctaw OK", "040025 Cimarron OK", "040027 Cleveland OK", "040029 Coal OK",
"040031 Comanche OK", "040033 Cotton OK", "040035 Craig OK", "040037 Creek OK",
"040039 Custer OK", "040041 Delaware OK", "040043 Dewey OK", "040045 Ellis OK"}

z4 = {"040047 Garfield OK", "040049 Garvin OK", "040051 Grady OK", "040053 Grant OK",
"040055 Greer OK", "040057 Harmon OK", "040059 Harper OK", "040061 Haskell OK",
"040063 Hughes OK", "040065 Jackson OK", "040067 Jefferson OK", "040069 Johnston OK",
"040071 Kay OK", "040073 Kingfisher OK", "040075 Kiowa OK", "040077 Latimer OK",
"040079 Le Flore OK", "040081 Lincoln OK", "040083 Logan OK", "040085 Love OK",
"040087 Mc Clain OK", "040089 Mc Curtain OK", "040091 Mc Intosh OK", "040093 Major OK",
"040095 Marshall OK", "040097 Mayes OK", "040099 Murray OK", "040101 Muskogee OK",
"040103 Noble OK", "040105 Nowata OK", "040107 Okfuskee OK", "040109 Oklahoma OK",
"040111 Okmulgee OK", "040113 Osage OK", "040115 Ottawa OK", "040117 Pawnee OK",
"040119 Payne OK", "040121 Pittsburg OK", "040123 Pontotoc OK", "040125 Pottawatomie OK"}

z5 = {"040127 Pushmataha OK", "040129 Roger Mills OK", "040131 Rogers OK", "040133 Seminole OK",
"040135 Sequoyah OK", "040137 Stephens OK", "040139 Texas OK", "040141 Tillman OK",
"040143 Tulsa OK", "040145 Wagoner OK", "040147 Washington OK", "040149 Washita OK",
"040151 Woods OK", "040153 Woodward OK", "048001 Anderson TX", "048003 Andrews TX",
"048005 Angelina TX", "048007 Aransas TX", "048009 Archer TX", "048011 Armstrong TX",
"048013 Atascosa TX", "048015 Austin TX", "048017 Bailey TX", "048019 Bandera TX",
"048021 Bastrop TX", "048023 Baylor TX", "048025 Bee TX", "048027 Bell TX", "048029 Bexar TX",
"048031 Blanco TX", "048033 Borden TX", "048035 Bosque TX", "048037 Bowie TX", "048039 Brazoria TX",
"048041 Brazos TX", "048043 Brewster TX", "048045 Briscoe TX", "048047 Brooks TX",
"048049 Brown TX", "048051 Burleson TX", "048053 Burnet TX", "048055 Caldwell TX"}

z6 = {"048057 Calhoun TX", "048059 Callahan TX", "048061 Cameron TX", "048063 Camp TX",
"048065 Carson TX", "048067 Cass TX", "048069 Castro TX", "048071 Chambers TX",
"048073 Cherokee TX", "048075 Childress TX", "048077 Clay TX", "048079 Cochran TX",
"048081 Coke TX", "048083 Coleman TX", "048085 Collin TX", "048087 Collingsworth TX",

"048089 Colorado TX", "048091 Comal TX", "048093 Comanche TX", "048095 Concho TX",
"048097 Cooke TX", "048099 Coryell TX", "048101 Cottle TX", "048103 Crane TX", "048105 Crockett TX",
"048107 Crosby TX", "048109 Culberson TX", "048111 Dallam TX", "048113 Dallas TX",
"048115 Dawson TX", "048117 Deaf Smith TX", "048119 Delta TX", "048121 Denton TX",
"048123 De Witt TX", "048125 Dickens TX", "048127 Dimmit TX", "048129 Donley TX",
"048131 Duval TX", "048133 Eastland TX", "048135 Ector TX", "048137 Edwards TX"}

z7 = {"048139 Ellis TX", "048141 El Paso TX", "048143 Erath TX", "048145 Falls TX",
"048147 Fannin TX", "048149 Fayette TX", "048151 Fisher TX", "048153 Floyd TX",
"048155 Foard TX", "048157 Fort Bend TX", "048159 Franklin TX", "048161 Freestone TX",
"048163 Frio TX", "048165 Gaines TX", "048167 Galveston TX", "048169 Garza TX",
"048171 Gillespie TX", "048173 Glasscock TX", "048175 Goliad TX", "048177 Gonzales TX",
"048179 Gray TX", "048181 Grayson TX", "048183 Gregg TX", "048185 Grimes TX",
"048187 Guadalupe TX", "048189 Hale TX", "048191 Hall TX", "048193 Hamilton TX",
"048195 Hansford TX", "048197 Hardeman TX", "048199 Hardin TX", "048201 Harris TX",
"048203 Harrison TX", "048205 Hartley TX", "048207 Haskell TX", "048209 Hays TX",
"048211 Hemphill TX", "048213 Henderson TX", "048215 Hidalgo TX", "048217 Hill TX"}

z8 = {"048219 Hockley TX", "048221 Hood TX", "048223 Hopkins TX", "048225 Houston TX",
"048227 Howard TX", "048229 Hudspeth TX", "048231 Hunt TX", "048233 Hutchinson TX",
"048235 Irion TX", "048237 Jack TX", "048239 Jackson TX", "048241 Jasper TX",
"048243 Jeff Davis TX", "048245 Jefferson TX", "048247 Jim Hogg TX", "048249 Jim Wells TX",
"048251 Johnson TX", "048253 Jones TX", "048255 Karnes TX", "048257 Kaufman TX",
"048259 Kendall TX", "048261 Kenedy TX", "048263 Kent TX", "048265 Kerr TX",
"048267 Kimble TX", "048269 King TX", "048271 Kinney TX", "048273 Kleberg TX",
"048275 Knox TX", "048277 Lamar TX", "048279 Lamb TX", "048281 Lampasas TX",
"048283 La Salle TX", "048285 Lavaca TX", "048287 Lee TX", "048289 Leon TX",
"048291 Liberty TX", "048293 Limestone TX", "048295 Lipscomb TX", "048297 Live Oak TX"}

z9 = {"048299 Llano TX", "048301 Loving TX", "048303 Lubbock TX", "048305 Lynn TX",

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    "048307 McCulloch TX", "048309 McLennan TX", "048311 McMullen
TX", "048313 Madison TX",
    "048315 Marion TX", "048317 Martin TX", "048319 Mason TX", "048321
Matagorda TX",
    "048323 Maverick TX", "048325 Medina TX", "048327 Menard TX", "048329
Midland TX",
    "048331 Milam TX", "048333 Mills TX", "048335 Mitchell TX", "048337
Montague TX",
    "048339 Montgomery TX", "048341 Moore TX", "048343 Morris TX", "048345
Motley TX",
    "048347 Nacogdoches TX", "048349 Navarro TX", "048351 Newton TX", "048353
Nolan TX",
    "048355 Nueces TX", "048357 Ochiltree TX", "048359 Oldham TX", "048361
Orange TX",
    "048363 Palo Pinto TX", "048365 Panola TX", "048367 Parker TX", "048369
Parmer TX",
    "048371 Pecos TX", "048373 Polk TX", "048375 Potter TX", "048377 Presidio
TX"}

z10 = {"048379 Rains TX", "048381 Randall TX", "048383 Reagan TX", "048385 Real
TX",
    "048387 Red River TX", "048389 Reeves TX", "048391 Refugio TX", "048393
Roberts TX",
    "048395 Robertson TX", "048397 Rockwall TX", "048399 Runnels TX", "048401
Rusk TX",
    "048403 Sabine TX", "048405 San Augustine TX", "048407 San Jacinto
TX", "048409 San Patricio TX",
    "048411 San Saba TX", "048413 Schleicher TX", "048415 Scurry TX", "048417
Shackelford TX",
    "048419 Shelby TX", "048421 Sherman TX", "048423 Smith TX", "048425
Somervell TX",
    "048427 Starr TX", "048429 Stephens TX", "048431 Sterling TX", "048433
Stonewall TX",
    "048435 Sutton TX", "048437 Swisher TX", "048439 Tarrant TX", "048441
Taylor TX",
    "048443 Terrell TX", "048445 Terry TX", "048447 Throckmorton TX", "048449
Titus TX",
    "048451 Tom Green TX", "048453 Travis TX", "048455 Trinity TX", "048457
Tyler TX"}

z11 = {"048459 Upshur TX", "048461 Upton TX", "048463 Uvalde TX", "048465 Val
Verde TX",
    "048467 Van Zandt TX", "048469 Victoria TX", "048471 Walker TX", "048473
Waller TX",
    "048475 Ward TX", "048477 Washington TX", "048479 Webb TX", "048481
Wharton TX",
    "048483 Wheeler TX", "048485 Wichita TX", "048487 Wilbarger TX", "048489
Willacy TX",
    "048491 Williamson TX", "048493 Wilson TX", "048495 Winkler TX", "048497
Wise TX",
    "048499 Wood TX", "048501 Yoakum TX", "048503 Young TX", "048505 Zapata
TX",
    "048507 Zavala TX"}

z12 = {"005001 Arkansas AR", "005005 Baxter AR", "005009 Boone AR",
    "005013 Calhoun AR", "005017 Chicot AR", "005021 Clay AR",
    "005025 Cleveland AR", "005029 Conway AR", "005033 Crawford AR",

```

```

"005037 Cross AR", "005041 Desha AR", "005045 Faulkner AR",
"005049 Fulton AR", "005053 Grant AR", "005057 Hempstead AR",
"005061 Howard AR", "005065 IZard AR", "005069 Jefferson AR",
"005073 Lafayette AR", "005077 Lee AR", "005081 Little River AR",
"005083 Logan AR", "005087 Madison AR", "005091 Miller AR",
"005095 Monroe AR", "005099 Nevada AR", "005103 Ouachita AR",
"005107 Phillips AR", "005111 Poinsett AR", "005115 Pope AR"}

z13 = {"005119 Pulaski AR", "005123 St Francis AR", "005127 Scott AR",
"005131 Sebastian AR", "005135 Sharp AR", "005139 Union AR",
"005143 Washington AR", "005147 Woodruff AR", "005003 Ashley AR",
"005007 Benton AR", "005011 Bradley AR", "005015 Carroll AR",
"005019 Clark AR", "005023 Cleburne AR", "005027 Columbia AR",
"005031 Craighead AR", "005035 Crittenden AR", "005039 Dallas AR",
"005043 Drew AR", "005047 Franklin AR", "005051 Garland AR",
"005055 Greene AR", "005059 Hot Spring AR", "005063 Independence AR",
"005067 Jackson AR", "005071 Johnson AR", "005075 Lawrence AR",
"005079 Lincoln AR", "005085 Lonoke AR", "005089 Marion AR"}

z14 = {"005093 Mississippi AR", "005097 Montgomery AR", "005101 Newton AR",
"005105 Perry AR", "005109 Pike AR", "005113 Polk AR",
"005117 Prairie AR", "005121 Randolph AR", "005125 Saline AR",
"005129 Searcy AR", "005133 Sevier AR", "005137 Stone AR",
"005141 Van Buren AR", "005145 White AR", "005149 Yell AR"}

cnty_fips = zadd+z1+z2+z3+z4+z5+z6+z7+z8+z9+z10+z11+z12+z13+z14

Dim counties[xcm]
  for j=1 to xcm do
    counties[j] = " "
  end

// Get the county names from the FIPS Codes
nfp = ArrayLength(cnty_fips)
for k=1 to xcm do
  kfips = rfips[k]
  cf = Lpad(Format(kfips,"*0"),6)
// Convert blanks to zeroes

  cf = Substitute(cf," ","0",)

  for j=1 to nfp do
    if cf = Substring(cnty_fips[j],1,6) then do
      counties[k] = Substring(cnty_fips[j],8,-1)
      goto cskip
    end
  end
end
cskip:
end

```

```

// Write Report of Total Employment, Productions, Attractions, and Scale
Factors by FIPS county
    commodity = {"AGRICULTURE           ", "RAW MATERIALS           ", "FOOD
",
                "TEXTILES             ", "WOOD                     ", "BUILDING
MATERIALS ",
                "MACHINERY            ", "MISCELLANIOUS           ", "SECONDARY
",
                "HAZARDOUS MATERIALS"}

    for j=1 to 10 do
        WriteLine(ptr_lst," ")
        WriteLine(ptr_lst,"                    "+commodity[j])
        WriteLine(ptr_lst,"
                                Total           Total
Total           Scale           Scale")
        WriteLine(ptr_lst," FIPS County           Employment   Shipping
Receiving       Shipping       Receiving")
        for k=1 to xcm do
            kfips = rfips[k]
            county = counties[k]
// cp[xcm], ca[xcm], cemp[xcm], pscale[xcm], ascale[xcm]
            cm = Lpad(R2s(kfips),5) + " "+Rpad(county,15)
                + Lpad(Format(cemp[k],"*0"),15)
                + Lpad(Format(cp[k][j],"*0"),13)
                + Lpad(Format(ca[k][j],"*0"),12)
                + Lpad(Format(pscale[k][j],"*0.000000"),17)
                + Lpad(Format(ascale[k][j],"*0.000000"),17)
            WriteLine(ptr_lst,cm)

        end

    end

// open the generation output data sets

    ptr_g1 = OpenFile(com_disag_gen1,"w")
    ptr_g2 = OpenFile(com_disag_gen2,"w")
    ptr_g3 = OpenFile(com_disag_gen3,"w")
    ptr_g4 = OpenFile(com_disag_gen4,"w")
    ptr_g5 = OpenFile(com_disag_gen5,"w")

// Begin insert 9/8/2005
// calculate and write P x A for 10 purposes
Dim p[10], a[10], amx[10], pmx[10]
for j=1 to 10 do
    p[j] = 0
    a[j] = 0
    pmx[j] = 1e-30
    amx[j] = 1e-30
end

// calculate Shipping s and attractions and write to 5 data sets
CreateProgressBar("Find Maximum Values", "True")
nbar = nbar + 1

```

```

    for jz=1 to mxzn do
      for k=1 to 10 do
        jfps = ac[jz]
        jc = fips[jfps]

        p[k] = totemp[jz]*pscale[jc][k]
        a[k] = totemp[jz]*ascale[jc][k]
// Find maximum P and A for 10 types
        pmx[k] = Max(p[k],pmx[k])
        amx[k] = Max(a[k],amx[k])
        perc=r2i((jz/mxzn)*100)
        stat=UpdateProgressBar("Find Maximum Values",perc)
      end
    end

// build 10 P and 10 A formats
Dim afmt[10],pfmt[10],nfmt[10]
nfmt = {
  "*0.000000000",
  "*0.00000000",
  "*0.0000000",
  "*0.000000",
  "*0.00000",
  "*0.0000",
  "*0.000",
  "*0.00",
  "*0.0",
  "*0"
}

for j=1 to 10 do
  jp = Log10(pmx[j]) + 2
  jp = R2i(jp)
  jp = Min(jp,10)
  jp = Max(jp,2)
  jp = R2i(jp)
  pfmt[j] = nfmt[jp]

  ja = Log10(amx[j]) + 2
  ja = R2i(ja)
  ja = Min(ja,10)
  ja = Max(ja,2)
  ja = R2i(ja)
  afmt[j] = nfmt[ja]

end
// End insert 9/8/2005

// calculate and write P x A for 10 purposes
Dim p[10], a[10]
for j=1 to 10 do
  p[j] = 0
  a[j] = 0
end

// calculate Shipping s and attractions and write to 5 data sets

```

```

CreateProgressBar("Write Generation Records", "True")
nbar = nbar + 1
for jz=1 to mxzn do
  for k=1 to 10 do
    jfps = ac[jz]
    jc = fips[jfps]

    p[k] = totemp[jz]*pscale[jc][k]
    a[k] = totemp[jz]*ascale[jc][k]
  end

// 503  FORMAT('GENERATION', I5, 2I12, 1X, 2I12, 1X, A10, I1, I4)
ZMOD263
perc=r2i((jz/mxzn)*100)
stat=UpdateProgressBar("Write Generation Records",perc)

  cg = "GENERATION" + Lpad(Format(jz,"*0"),5)
+Lpad(Format(p[1],pfmt[1]),12)+Lpad(Format(a[1],afmt[1]),12)
  +Lpad(Format(p[2],pfmt[2]),13)+Lpad(Format(a[2],afmt[2]),12)+"
AGRICULTURE , RAW MATERIALS"
  WriteLine(ptr_g1,cg)
  cg = "GENERATION"+ Lpad(Format(jz,"*0"),5)
+Lpad(Format(p[3],pfmt[3]),12)+Lpad(Format(a[3],afmt[3]),12)
  +Lpad(Format(p[4],pfmt[4]),13)+Lpad(Format(a[4],afmt[4]),12) +
" FOOD, TEXTILES"
  WriteLine(ptr_g2,cg)

  cg = "GENERATION" + Lpad(Format(jz,"*0"),5)
+Lpad(Format(p[5],pfmt[5]),12)+Lpad(Format(a[5],afmt[5]),12)
  +Lpad(Format(p[6],pfmt[6]),13)+Lpad(Format(a[6],afmt[6]),12) +
" WOOD, BUILDING MATERIALS"
  WriteLine(ptr_g3,cg)
  cg = "GENERATION"+ Lpad(Format(jz,"*0"),5)
+Lpad(Format(p[7],pfmt[7]),12)+Lpad(Format(a[7],afmt[7]),12)
  +Lpad(Format(p[8],pfmt[8]),13)+Lpad(Format(a[8],afmt[8]),12)+
" MACHINERY, MISCELLANIOUS"
  WriteLine(ptr_g4,cg)

  cg = "GENERATION"+ Lpad(Format(jz,"*0"),5)
+Lpad(Format(p[9],pfmt[9]),12)+Lpad(Format(a[9],afmt[9]),12)

+Lpad(Format(p[10],pfmt[10]),13)+Lpad(Format(a[10],afmt[10]),12)+ "
SECONDARY, HAZARDOUS MATERIALS"
  WriteLine(ptr_g5,cg)

end

normal_end:
  if nrr = 0 then ShowMessage("Processed "+R2s(mxzn)+" zones without
errors.")
  if nrr <> 0 then ShowMessage(R2s(nrr)+" Errors occured.")

  if nbar > 0 then do

```

```

    for j=1 to nbar do
        destroyprogressbar()
    end
end
Return()

// Trap some other Transcad errors
on Error goto error_end
on NotFound goto error_end
on Escape goto error_end
on NonUnique goto error_end
on Missing goto error_end
on DivideByZero goto error_end
on EndOfFile goto error_end
//    on Locked goto error_end
on LanguageError goto error_end

error_end:
    last_err = GetLastError()
    ShowMessage(last_err)
    goto normal_end

EndMacro

```


**APPENDIX C:
COMMERCIAL VEHICLE SURVEY ANALYSIS PROGRAM FOR THE
HOUSTON-GALVESTON AREA**


```

PROGRAM COMVEH8
C
C PURPOSE OF PROGRAM IS TO INPUT COMMERCIAL VEHICLE SURVEY DATA
C WITH MAJORITY OF SERVICE VEHICLES REMOVED FROM
C HOUSTON AND DEVELOP ESTIMATES OF TRUCK TRIPS AND COMMODITY LOADS
C OF SHIPPING AND RECEIVING BY LAND USE ACTIVITY AND VEHICLE CLASS
C
C THIS VERSION IS DATED 5-15-2005
C USES UPDATED LOAD TABLE
C
  DIMENSION LCODE(20),TOURS(5),STPS(5,50),SHIP(5,9,20),
* TSHIP(5,9,20),RCVD(5,9,20),TRCVD(5,9,20),EMPTY(5,9,20),
* EMPTY(5,9,20),RT1(20),RT2(20),WDST(12,5),PWT(100),
* SHIPM(3,9,12),TSHIPM(3,9,12),RCVDM(3,9,12),TRCVDM(3,9,12),
* EMPTYS(3,9,12),EMPTYR(3,9,12)

  CHARACTER*150 CRD,REC(100)
  CHARACTER*40 COMOD(20)
  CHARACTER*10 CHG,TRK
  CHARACTER*35 CLASS(5),GRPCLS(3)
  CHARACTER*12 ACTIVITY(9),RTOT
  CHARACTER*20 GRP(12)

  OPEN(2,FILE='REC2021.MVE')
C   OPEN(2,FILE='REC2021.COR')
C   OPEN(2,FILE='TEST')
C   OPEN(2,FILE='R2021.TMP')

  OPEN(3,FILE='COMTRP8.HOU')
  OPEN(4,FILE='COM8COR.OUT')
  OPEN(7,FILE='TEMP8COR.CV')
  OPEN(8,FILE='DEBUG8.COR')
  OPEN(9,FILE='REVWT.CV')

  CLASS(1) = 'SINGLE UNIT 2-AXLE'
  CLASS(2) = 'SINGLE UNIT 3-AXLE'
  CLASS(3) = 'SINGLE UNIT 4-AXLE'
  CLASS(4) = 'TRACTOR TRAILER COMBINATION'
  CLASS(5) = 'UNKNOWN'

  GRPCLS(1) = 'SMALL/MEDIUM VEHICLES'
  GRPCLS(2) = 'HEAVY DUTY VEHICLES'
  GRPCLS(3) = 'UNKNOWN'

  ACTIVITY(1) = 'RESIDENTIAL'
  ACTIVITY(2) = 'EDUCATIONAL'
  ACTIVITY(3) = 'INDUSTRIAL'
  ACTIVITY(4) = 'GOVERNMENT'
  ACTIVITY(5) = 'MEDICAL'
  ACTIVITY(6) = 'OFFICE'
  ACTIVITY(7) = 'RETAIL'
  ACTIVITY(8) = 'OTHER'
  ACTIVITY(9) = 'UNKNOWN'

  COMOD(1) = 'FARM PRODUCTS'
  LCODE(1) = 1
  COMOD(2) = 'FOREST PRODUCTS'

```

```

LCODE(2) = 8
COMOD(3) = 'MARINE PRODUCTS'
LCODE(3) = 9
COMOD(4) = 'METALS AND MINERALS'
LCODE(4) = 10
COMOD(5) = 'FOOD, HEALTH, AND BEAUTY PRODUCTS'
LCODE(5) = 20
COMOD(6) = 'TOBACCO PRODUCTS'
LCODE(6) = 21
COMOD(7) = 'TEXTILES'
LCODE(7) = 22
COMOD(8) = 'WOOD PRODUCTS'
LCODE(8) = 26
COMOD(9) = 'PRINTED MATTER'
LCODE(9) = 27
COMOD(10) = 'CHEMICAL PRODUCTS'
LCODE(10) = 28
COMOD(11) = 'REFINED PETROLEUM OR COAL PRODUCTS'
LCODE(11) = 29
COMOD(12) = 'RUBBER, PLASTIC, AND STYROFOAM PRODUCTS'
LCODE(12) = 30
COMOD(13) = 'CLAY, CONCRETE, GLASS, OR STONE'
LCODE(13) = 32
COMOD(14) = 'MANUFACTURED GOODS/EQUIPMENT'
LCODE(14) = 38
COMOD(15) = 'WASTES'
LCODE(15) = 40
COMOD(16) = 'MISCELLANEOUS SHIPMENTS'
LCODE(16) = 41
COMOD(17) = 'HAZARDOUS MATERIALS'
LCODE(17) = 49
COMOD(18) = 'UNCLASSIFIED CARGO'
LCODE(18) = 60
COMOD(19) = 'UNKNOWN TO DRIVER'
LCODE(19) = 98
COMOD(20) = 'EMPTY'
LCODE(20) = 99

GRP(1) = 'AGRICULTURE'
GRP(2) = 'RAW MATERIALS'
GRP(3) = 'FOOD'
GRP(4) = 'TEXTILES'
GRP(5) = 'WOOD'
GRP(6) = 'BUILDING MATERIALS'
GRP(7) = 'MACHINERY'
GRP(8) = 'MISCELLANEOUS'
GRP(9) = 'SECONDARY'
GRP(10) = 'HAZARDOUS'
GRP(11) = 'UNKNOWN'
GRP(12) = 'EMPTY'

```

C

```

C INPUT WEIGHT DISTRIBUTION PCT FOR VEHICLES BY CLASS (5) AND COMMODITY (10)
  DO 40 I = 1,11
    READ(9,41) (WDST(I,J),J=1,5)
41  FORMAT(5F10.3)
40  CONTINUE

```

```

    IFR = 0
    CHG = ' '
1 CONTINUE
    READ(2,2,END=4) CRD
2 FORMAT(A150)

    IF(CRD(1:2).EQ.'20') THEN

        READ(CRD,3) IVC,GVWT
3 FORMAT(100X,32X,I2,F6.0)

        IF(IFR.NE.0) CALL COMB(REC,KVC,IR,WT)

        IF(IVC.EQ.1.AND.GVWT.LT.10000.0) THEN
C          WT = 0.25*GVWT
            WT = GVWT
            KVC = 1
            END IF

        IF(IVC.EQ.1.AND.GVWT.GE.10000.0) THEN
C          WT = 0.30*GVWT
            WT = GVWT
            KVC = 2
            END IF

        IF(IVC.EQ.2) THEN
C          WT = 0.5*GVWT
            WT = GVWT
            KVC = 3
            END IF

        IF(IVC.EQ.3) THEN
C          WT = 0.6*GVWT
            WT = GVWT
            KVC = 4
            END IF

        IF(IVC.LE.0.OR.IVC.GT.4.OR.IVC.EQ.4) THEN
C          WT = 0.5*GVWT
            WT = GVWT
            KVC = 5
            END IF

        IR = 0
        IFR = 1

        DO 10 L = 1,50
            REC(L) = ' '
10 CONTINUE

        GO TO 1

        END IF

        IF(CRD(1:2).EQ.'21') THEN

```

```

        IR = IR + 1
        REC(IR) = CRD
        GO TO 1

    END IF

4 CONTINUE

    CALL COMB(REC,KVC,IR,WT)

    REWIND 3

    DO 9 MM = 1,100
        REC(MM) = ' '
9 CONTINUE
        CHG = ' '
        IT = 0
        IFR = 0
5 CONTINUE

        READ(3,2,END=6) CRD

        READ(CRD,7) KVC,WT,JCAR
7        FORMAT(11X,I3,F8.0,18X,I3)

        SAVEWT = WT

        CALL MTCH(JCAR,LCODE,KJC)
        IF(KJC.GT.11) WDST(KJC,KVC) = 0.0
        WT = WT*WDST(KJC,KVC)

        WRITE(8,2999) CRD(1:10),KVC,KJC,JCAR,WDST(KJC,KVC),WT,SAVEWT
2999    FORMAT(A10,' KVC ',I3,' KJC ',I3,' JCAR ',I3,' WDST ',F8.3,
* ' WEIGHT ',F10.2,' GROSS VEH WT ',F10.2)

        IF(IT.LT.100) THEN
            WRITE(8,200) IT,CRD(2:11),CHG
200    FORMAT(2X,'IT ',I3,' CRD ',A10,' CHG ',A10)
            END IF

        IF(CRD(2:11).NE.CHG.AND.IFR.NE.0) THEN
            CALL TSUM(IT,REC,PWT,LCODE,TOURS,STPS)

            DO 8 MM = 1,100
                REC(MM) = ' '
                PWT(MM) = 0.
8 CONTINUE
                IT = 0
                IFR = 1
            END IF

            IT = IT + 1
            REC(IT) = CRD
            PWT(IT) = WT
            CHG = CRD(2:11)

```

```

IFR = 1

GO TO 5

6 CONTINUE

CALL TSUM(IT,REC,PWT,LCODE,TOURS,STPS)

C OUTPUT RESULTS

CALL TSUM2(IT,REC,PWT,LCODE,TOURS,STPS,SHIP,TSHIP,RCVD,TRCVD,
*          EMPTY,EMPTY,ACTITY,GRP,
*          SHIPM,TSHIPM,RCVDM,TRCVDM,EMPTYYS,EMPTYR)

DO 20 I = 1,5
  WRITE(4,100) CLASS(I),TOURS(I)
100  FORMAT(5X,'NUMBER OF TOURS FOR ',A35,' WAS ',F12.0//
* 2X,'DISTRIBUTION OF TOURS BY NUMBER OF STOPS '/
* 5X,'NO. STOPS ',5X,'NO. TOURS'/)
  DO 21 J = 1,50
    IF(STPS(I,J).LE.0.0) GO TO 21
    WRITE(4,101) J,STPS(I,J)
101  FORMAT(5X,3X,I5,6X,F8.0)
  21 CONTINUE
  20 CONTINUE

  RTOT = 'TOTAL'

DO 28 I = 1,5
  WRITE(4,102) CLASS(I)
102  FORMAT(5X,A35,' SHIPPING DATA')

  WRITE(4,103) (ACTITY(J),J=1,5)
103  FORMAT(//42X,34X,'LAND USE ACTIVITY'/7X,'TYPE OF CARGO',31X,
* 5(3X,A12,2X)/1X,128('='))

DO 33 J = 1,20
  RT1(J) = 0.
  RT2(J) = 0.
DO 22 L = 1,9
  RT1(J) = RT1(J) + SHIP(I,L,J)
  RT2(J) = RT2(J) + TSHIP(I,L,J)
22 CONTINUE

  WRITE(4,104) COMOD(J),(SHIP(I,K,J),K=1,5),(TSHIP(I,K,J),K=1,5)
104  FORMAT(2X,A40,2X,'LBS ',2X,5(3X,F12.2,2X)/
* 44X,'TRIPS',2X,5(3X,F12.0,2X))

33 CONTINUE

  WRITE(4,103) (ACTITY(J),J=6,9),RTOT

DO 23 J = 1,20
  WRITE(4,104) COMOD(J),(SHIP(I,K,J),K=6,9),RT1(J),
* (TSHIP(I,K,J),K=6,9),RT2(J)

```

```

23 CONTINUE
28 CONTINUE

      RTOT = 'TOTAL'

DO 24 I = 1,5
  WRITE(4,105) CLASS(I)
105  FORMAT(5X,A35,' RECEIVING DATA')

      WRITE(4,103) (ACTITY(J),J=1,5)

DO 25 J = 1,20
  RT1(J) = 0.
  RT2(J) = 0.
DO 26 L = 1,9
  RT1(J) = RT1(J) + RCVD(I,L,J)
  RT2(J) = RT2(J) + TRCVD(I,L,J)
26 CONTINUE

      WRITE(4,104) COMOD(J),(RCVD(I,K,J),K=1,5),(TRCVD(I,K,J),K=1,5)

25 CONTINUE

      WRITE(4,103) (ACTITY(J),J=6,9),RTOT

DO 27 J = 1,20
  WRITE(4,104) COMOD(J),(RCVD(I,K,J),K=6,9),RT1(J),
*          (TRCVD(I,K,J),K=6,9),RT2(J)
27 CONTINUE
24 CONTINUE

      RTOT = 'TOTAL'

DO 29 I = 1,5
  WRITE(4,106) CLASS(I)
106  FORMAT(5X,A35,' NO TRANSFER DATA')

      WRITE(4,103) (ACTITY(J),J=1,5)

DO 30 J = 1,20
  RT1(J) = 0.
  RT2(J) = 0.
DO 31 L = 1,9
  RT1(J) = RT1(J) + SEMPTY(I,L,J)
  RT2(J) = RT2(J) + REMPTY(I,L,J)
31 CONTINUE

      WRITE(4,107) COMOD(J),(SEMPTY(I,K,J),K=1,5),
*          (REMPY(I,K,J),K=1,5)

30 CONTINUE

      WRITE(4,103) (ACTITY(J),J=6,9),RTOT

DO 32 J = 1,20

```



```

        WRITE(4,107) COMOD(J), (SEMPY(I,K,J),K=6,9),RT1(J),
*          (REMPY(I,K,J),K=6,9),RT2(J)
107  FORMAT(2X,A40,2X,'SHIP ',2X,5(3X,F12.2,2X)/
*          44X,'RCVD ',2X,5(3X,F12.0,2X))

```

32 CONTINUE

29 CONTINUE

C
C
C

OUTPUT RESULTS FOR COMMODITY GROUPS BEING MODELED

```

        DO 42 I = 1,3
          WRITE(4,102) GRPCLS(I)
          WRITE(4,108) (ACTITY(J),J=1,9),RTOT
108  FORMAT(/42X,34X,'LAND USE ACTIVITY'/7X,'TYPE OF CARGO',5X,
* 10(1X,A12)/)
          DO 43 J = 1,12
            RT1(J) = 0.
            RT2(J) = 0.
          DO 44 L = 1,9
            RT1(J) = RT1(J) + SHIPM(I,L,J)
            RT2(J) = RT2(J) + TSHIPM(I,L,J)
44  CONTINUE
          WRITE(4,109) GRP(J), (SHIPM(I,L,J),L=1,9),RT1(J),
*          (TSHIPM(I,L,J),L=1,9),RT2(J)
109  FORMAT(1X,A20,2X,'LBS ',10(1X,F11.2)/23X,'TRPS ',10(1X,F11.2))
43  CONTINUE
42  CONTINUE

```

```

        DO 45 I = 1,3
          WRITE(4,105) GRPCLS(I)
          WRITE(4,108) (ACTITY(J),J=1,9),RTOT

```

```

        DO 46 J = 1,12
          RT1(J) = 0.
          RT2(J) = 0.
        DO 47 L = 1,9
          RT1(J) = RT1(J) + RCVDM(I,L,J)
          RT2(J) = RT2(J) + TRCVDM(I,L,J)
47  CONTINUE
          WRITE(4,109) GRP(J), (RCVDM(I,L,J),L=1,9),RT1(J),
*          (TRCVDM(I,L,J),L=1,9),RT2(J)
46  CONTINUE
45  CONTINUE

```

```

        DO 48 I = 1,3
          WRITE(4,106) GRPCLS(I)
          WRITE(4,108) (ACTITY(J),J=1,9),RTOT

```

```

        DO 49 J = 1,12
          RT1(J) = 0.
          RT2(J) = 0.
        DO 50 L = 1,9
          RT1(J) = RT1(J) + EMPTY(S,I,L,J)
          RT2(J) = RT2(J) + EMPTYR(I,L,J)
50  CONTINUE

```

```

        WRITE(4,110) GRP(J), (EMPTYYS(I,L,J),L=1,9),RT1(J),
*          (EMPTYR(I,L,J),L=1,9),RT2(J)
110  FORMAT(1X,A20,2X,'SHP ',10(1X,F11.2)/23X,'RCV ',10(1X,F11.2))
49  CONTINUE
48  CONTINUE

```

```

STOP
END

```

```

SUBROUTINE COMB(REC,IVC,IR,WT)
CHARACTER*10 TRK,TRK2
CHARACTER*150 REC(100)

```

```

IF(IVC.LE.0.OR.IVC.GT.4) IVC = 5

```

```

READ(REC(1),1) TRK,IZNO,IWI,ICAR,IPUR,IACT,IARVHR,IARVMN,
*  IODOM,IDPTHR,IDPTMN,DISTO,TIMO

```

```

1  FORMAT(2X,A10,42X,I5,I1,I2,2I1,2I2,I7,2I2,2F7.2)

```

```

DO 3 I = 2,IR

```

```

READ(REC(I),1) TRK2,JZND,JWI,JCAR,JPUR,JACT,JARVHR,JARVMN,
*  JODOM,JDPTH,JDPTMN,DISTD,TIMD

```

```

WRITE(3,2) TRK,IVC,WT,IWI,JWI,IACT,JACT,IPUR,JPUR,JCAR,IZNO,
*  JZND,IDPTHR,IDPTMN,JARVHR,JARVMN,IODOM,JODOM,DISTD,TIMD

```

```

2  FORMAT(1X,A10,I3,F8.0,7I3,2I5,4I3,2I8,2F8.2)

```

```

IWI = JWI
IACT = JACT
IPUR = JPUR
ICAR = JCAR
IZNO = JZND
IDPTHR = JDPTH
IDPTMN = JDPTMN
IODOM = JODOM
DISTO = DISTD
TIMO = TIMD

```

```

3  CONTINUE

```

```

RETURN
END

```

```

SUBROUTINE TSUM(IT,REC,PWT,LCODE,TOURS,STPS)

```

```

DIMENSION IB(100),IE(100),NSTP(50),STPS(5,50),TOURS(5),
*  RC(25,3),MPT(50),TWT(50),PWT(100),
*  LCODE(20)

```

```

CHARACTER*150 REC(100)

```

```

C  IT IS NUMBER OF TRIPS FOR A VEHICLE
C  REC CONTAINS THE DATA FOR EACH TRIP
C  ITR IS THE NUMBER OF TOURS MADE BY VEHICLE
C

```

```

DO 16 MM = 1,50
  NSTP(MM) = -1.0
16 CONTINUE

  ITR = 0
  J = 0
  IFR = 0

DO 1 I = 1,IT
C
C INPUT INDICATORS AT ORIGIN AND DESTINATION OF LOCATION BEING BASE
C
  READ(REC(I),2) IVC,IWO,IWD
  2 FORMAT(11X,I3,8X,2I3)

C IF FIRST TRIP AND ORIGIN IS NOT BASE SKIP UNTIL FIND TRIP WITH ORIGIN AS
C BASE

  IF(IWO.NE.1.AND.IFR.EQ.0) GO TO 1

  IF(IWO.EQ.1) THEN
    J = J + 1
    ITR = ITR +1
C
C SET POINTER FOR TRIP THAT TOUR BEGINS
C
    IB(J) = I
    IFR = 1
    N = 0

    END IF

    NSTP(ITR) = NSTP(ITR) + 1

    IF(I.EQ.IT.OR.IWD.EQ.1) THEN

      IE(J) = I

    END IF

    1 CONTINUE

C SAVE NUMBER OF TOURS J

  MS = J
  WRITE(8,17) REC(1)(2:11),MS
17 FORMAT(2X,A10,' HAS ',I2,' TOURS'/)

C SUM NUMBER OF TOURS BY VEHICLE CLASS

  IF(IVC.LE.0.OR.IVC.GT.5) THEN
    WRITE(8,200) IT,REC(1),REC(2)
200 FORMAT(2X,'IVC ',I3/1X,'REC ',A150/1X,'REC ',A150)
    STOP 1
  END IF

```

```

        TOURS(IVC) = TOURS(IVC) + ITR
C   SUM NUMBER OF TOURS BY NUMBER OF STOPS BY VEHICLE CLASS

        DO 3 K = 1,ITR
          IF(NSTP(K).LE.0) THEN
            WRITE(8,300) K,REC(1)
300      FORMAT(2X,'NO. STOPS WAS 0 FOR K = ',I2/A150)
            GO TO 3
          END IF
          STPS(IVC,NSTP(K)) = STPS(IVC,NSTP(K)) + 1.0
        3 CONTINUE

C   BEGIN PROCESS OF SUMMING NUMBER OF SEQUENTIAL TYPES OF STOPS, I.E.,
C   DELIVERIES, PICKUPS, OTHER
C

        DO 40 I = 1,25
          DO 40 NN = 1,3
            RC(I,NN) = 0.
40      CONTINUE

        DO 4 I = 1,MS

          J = IB(I)
          K = IE(I)

          WRITE(8,203) REC(1)(2:11),I,IB(I),IE(I)
203      FORMAT(2X,A10,2X,'I ',I3,' IB ',I3,' IE ',I3)

C   ZERO OUT COUNTERS FOR EACH TOUR

        DO 49 MJ = 1,25
          RC(MJ,1) = 0.
          RC(MJ,2) = 0.
          RC(MJ,3) = 0.
49      CONTINUE

          KPV = 0
          JJ = 0

          DO 5 L = J,K-1
C
C   INPUT THE PURPOSE FROM AND PURPOSE TO FOR TRIP AND SET CODE INDICATING
C   IF PURPOSE AT DESTINATION IS OTHER (3), DELIVERY (1), PICKUP (2)

            READ(REC(L),6) IPO,IPD
6          FORMAT(34X,2I3)

            IA = 3
            IF(IPD.EQ.2) IA = 1
            IF(IPD.EQ.3) IA = 2
C          IF(IA.EQ.3) GO TO 53

            IF(KPV.NE.IPD.AND.IPD.LE.3) THEN
              JJ = JJ + 1

```

```

        END IF

C   RC SUMS THE NUMBER OF TIMES THE PURPOSE AT THE DESTINATION IS THE SAME
        IF(JJ.LE.0) GO TO 5
        RC(JJ,IA) = RC(JJ,IA) + 1.0

C   KPV STORES THE PREVIOUS DESTINATION PURPOSE
53  CONTINUE
        IF(IPD.LE.3) KPV = IPD

C   MPT POINTS TO THE TRIPS THAT HAVE THE SAME DESTINATION PURPOSE
        MPT(L) = JJ

5   CONTINUE
        DO 51 L = J,K-1
        JJ = MPT(L)

        IF(JJ.LE.0) GO TO 51
        WRITE(8,201) REC(1)(2:11),L,MPT(L),RC(JJ,1),RC(JJ,2),RC(JJ,3),
*   PWT(L)
201  FORMAT(2X,A10,2X,'L ',I2,' MPT ',I3,' RC1 ',F5.0,' RC2 ',F5.0,
*   ' RC3 ',F5.0,' PWT ',F10.2)
51  CONTINUE

C   JSV SAVES THE NUMBER OF TIMES THE DESTINATION PURPOSE CHANGES
        JSV = JJ

C   FOR EACH SERIES OF TRIPS WITH SAME DESTINATION PURPOSE, COMPUTE
C   THE ESTIMATED WEIGHT OF CARGO THAT IS RECEIVED OR PICKUP AT THAT TRIP
        L = J
500  CONTINUE
C   INPUT WORK INDICATOR AND TRIP PURPOSES AT ORIGIN & DESTINATION ON TRIP
RECORD
        READ(REC(L),61) IWO,IWD,IPO,IPD
61   FORMAT(22X,2I3,6X,2I3)

C   SET POINTER FOR INDEX IN VARIABLE THAT SUMMED SEQUENTIAL NO. OF PURPOSES
        JJ = MPT(L)

C   BEGIN CHECKS FOR ORIGIN AT BASE LOCATION
        IF(IWO.EQ.1.OR.IPO.EQ.1) THEN

C   ORIGIN OF TRIP IS BASE, NOW CHECK DESTINATION PURPOSES
C   FIRST IS IF DESTINATION IS FOR DELIVERY, IF SO SHIP WT IS MAX AND
RECEIVING
C   WEIGHT IS PROPORTION OF CARGO BASED ON NUMBER OF SEQUENTIAL DELIVERIES
        IF(IPD.EQ.2) THEN
            SHIP = PWT(L)

```

```

        RCVD = PWT(L)/RC(MPT(L),1)
        KEMPTY = 1
        GO TO 50
    END IF

C CHECK FOR DESTINATION BEING A CARGO PICKUP, IF SO THEN SHIP WT IS 0 AND
C RECEIVING WT IS 0

        IF(IPD.EQ.3) THEN
            SHIP = 0.
            RCVD = 0.
            KEMPTY = 0
            GO TO 50
        END IF

C CHECK FOR DESTINATION BEING SOMETHING BESIDES DELIVERY OR PICK UP
C IF SO, THEN READ FOLLOWING TRIP RECORDS UNTIL FIND A DELIVERY OR PICKUP
C THEN SET CARGO WT ACCORDINGLY

        IF(IPD.GT.3) THEN
            M = L
62 CONTINUE
            M = M + 1
            IF(M.GT.K) THEN
C ALL FOLLOWING TRIPS READ AND NONE WERE DELIVERY OR PICK UP SO SET
C SHIP AND RECEIVE WT TO 0
                SHIP = 0.
                RCVD = 0.
                KEMPTY = 0
                GO TO 50
            END IF

            READ(REC(M),61) KWO,KWD,KPO,KPD
            IF(KPD.EQ.2) THEN
                SHIP = PWT(M)
                RCVD = 0.0
                KEMPTY = 1
                GO TO 50
            END IF
            IF(KPD.EQ.3) THEN
                SHIP = 0.
                RCVD = 0.
                KEMPTY = 0
                GO TO 50
            END IF
            IF(KPD.GT.3.OR.(KPD.EQ.1.OR.KWD.EQ.1)) GO TO 62
        END IF

    END IF

C CHECK TRIP IF ORIGIN WAS A DELIVERY
    IF(IPO.EQ.2) THEN

C CHECK TRIP DESTINATION TO SEE IF BASE LOCATION
        IF(IPD.EQ.1.OR.IWD.EQ.1) THEN
            SHIP = 0.
            RCVD = 0.

```

```

        KEMPTY = 0
        GO TO 50
    END IF

C CHECK TRIP DESTINATION TO SEE IF ANOTHER DELIVERY, IF SO, THEN SHIP WT
C IS 0 AND RECEIVING WT IS PROPORTION BASED ON NO SEQUENTIAL DELIVERIES
    IF(IPD.EQ.2) THEN
        SHIP = 0.
        RCVD = PWT(L)/RC(JJ,1)
        KEMPTY = 1
    END IF

C CHECK TRIP DESTINATION TO SEE IF IT IS PICK UP, THEN SHIP WT IS 0 AND
C RECEIVING WT IS 0
    IF(IPD.EQ.3) THEN
        SHIP = 0.
        RCVD = 0.
        KEMPTY = 0
        GO TO 50
    END IF

C CHECK DESTINATION TO SEE IF OTHER, THEN READ FOLLOWING TRIPS UNTIL FIND
C A DELIVERY OR PICK UP AND SET WEIGHTS ACCORDINGLY
    IF(IPD.GT.3) THEN
        M = L
63 CONTINUE
        M = M + 1
        IF(M.GT.K) THEN
C NO TRIPS FOUND WITH DELIVERY OR PICK UP SO SET WTS TO 0
            SHIP = 0.
            RCVD = 0.
            KEMPTY = 0
            GO TO 50
        END IF

        READ(REC(M),61) KWO,KWD,KPO,KPD
        IF(KPD.EQ.2) THEN
            SHIP = 0.
            RCVD = 0.
            KEMPTY = 1
            GO TO 50
        END IF
        IF(KPD.EQ.3) THEN
            SHIP = 0.
            RCVD = 0.
            KEMPTY = 0
            GO TO 50
        END IF
        IF(KPD.GT.3.OR.(KPD.EQ.1.OR.KWD.EQ.1)) GO TO 63
    END IF

    END IF

C CHECK TRIP IF ORIGIN WAS PICK UP
    IF(IPO.EQ.3) THEN

C CHECK DESTINATION TO SEE IF BASE STATION

```

```

        IF(IPD.EQ.1.OR.IWD.EQ.1) THEN
            SHIP = PWT(L-1)/RC(MPT(L-1),2)
            RCVD = PWT(L)
            KEMPTY = 1
            GO TO 50
        END IF

C CHECK DESTINATION TO SEE IF IT IS A DELIVERY
        IF(IPD.EQ.2) THEN
            SHIP = PWT(L)/RC(MPT(L-1),2)
            RCVD = PWT(L)/RC(MPT(L),1)
            KEMPTY = 1
            GO TO 50
        END IF

C CHECK DESTINATION TO SEE IF IT IS A PICK UP
        IF(IPD.EQ.3) THEN
            SHIP = PWT(L)/RC(MPT(L-1),2)
            RCVD = 0.
            KEMPTY = 1
            GO TO 50
        END IF

C CHECK DESTINATION TO SEE IF IT IS OTHER, IF YES, THEN READ FOLLOWING
C TRIPS UNTIL FIND A DELIVERY OR PICK UP

        IF(IPD.GT.3) THEN
            M = L
64 CONTINUE
            M = M + 1
            IF(M.GT.K) THEN
C NO TRIPS FOUND WITH DELIVERY OR PICK UP SO SET SHIP AND RECEIVING TO 0
                SHIP = PWT(L-1)/RC(MPT(L-1),2)
                RCVD = 0.
                KEMPTY = 1
                GO TO 50
            END IF
            READ(REC(M),61) KWO,KWD,KPO,KPD
            IF(KPD.EQ.2) THEN
                SHIP = PWT(L-1)/RC(MPT(L-1),2)
                RCVD = 0.
                KEMPTY = 1
                GO TO 50
            END IF
            IF(KPD.EQ.3) THEN
                SHIP = PWT(L-1)/RC(MPT(L-1),2)
                RCVD = 0.
                KEMPTY = 1
            END IF
            IF(KPD.GT.3.OR.(KPD.EQ.1.OR.KWD.EQ.1)) GO TO 64
        END IF

        END IF

C CHECK TRIP WHERE ORIGIN WAS NOT DELIVERY OR PICK UP
        IF(IPO.GT.3) THEN

```



```

C CHECK IF DESTINATION IS BASE
  IF(IPD.EQ.1.OR.IWD.EQ.1) THEN
C CHECK PREVIOUS TRIP TO IDENTIFY ORIGIN PURPOSE
  READ(REC(L-1),61) KWO,KWD,KPO,KPD
  IF(KPO.EQ.2) THEN
    SHIP = 0.
    RCVD = 0.
    KEMPTY = 0
    GO TO 50
  END IF
  IF(KPO.EQ.3) THEN
    SHIP = 0.
    RCVD = PWT(L)
    KEMPTY = 1
    GO TO 50
  END IF
  SHIP = 0.
  RCVD = 0.
  KEMPTY = 0
  GO TO 50
END IF

C CHECK IF DESTINATION IS A DELIVERY
  IF(IPD.EQ.2) THEN
C CHECK PREVIOUS TRIP TO IDENTIFY ORIGIN PURPOSE
  READ(REC(L-1),61) KWO,KWD,KPO,KPD
  IF(KPO.EQ.2) THEN
    SHIP = 0.
    RCVD = PWT(L-1)/RC(MPT(L-1),1)
    KEMPTY = 1
    GO TO 50
  END IF
  IF(KPO.EQ.3) THEN
    SHIP = 0.
    RCVD = PWT(L)/RC(MPT(L),1)
    KEMPTY = 1
    GO TO 50
  END IF
  IF(KPO.EQ.1.OR.KWO.EQ.1) THEN
    SHIP = 0.
    RCVD = PWT(L)/RC(MPT(L),1)
    KEMPTY = 1
    GO TO 50
  END IF
END IF

C CHECK DESTINATION TO SEE IF A PICK UP
  IF(IPD.EQ.3) THEN
C CHECK PREVIOUS TRIP TO IDENTIFY ORIGIN PURPOSE
  READ(REC(L-1),61) KWO,KWD,KPO,KPD
  IF(KPO.EQ.2) THEN
    SHIP = 0.
    RCVD = 0.
    KEMPTY = 0
    GO TO 50
  END IF
  IF(KPO.EQ.3) THEN

```

```

        SHIP = 0.
        RCVD = 0.
        KEMPTY = 1
        GO TO 50
    END IF
    SHIP = 0.
    RCVD = 0.
    KEMPTY = 0
    GO TO 50
END IF

C CHECK DESTINATION TO SEE IF PURPOSE IS OTHER, IF SO, THEN SET SHIP AND
C RECEIVING WTS TO 0
    IF(IPD.GT.3) THEN
        SHIP = 0.
        RCVD = 0.
        KEMPTY = 0
        GO TO 50
    END IF

    END IF

50 CONTINUE
C WRITE TRIP TO TEMPORARY FILE WITH SHIPPING AND RECEIVING WEIGHTS AS
C WELL AS INDICATOR THAT TRIP SEGMENT WAS EMPTY (0) OR NOT (1)

    WRITE(7,9) REC(L),SHIP,RCVD,KEMPTY,PWT(L)
9    FORMAT(A97,2F10.1,I5,F10.2)
    L = L + 1
    IF(L.GT.K) GO TO 52
    GO TO 500
52 CONTINUE

4 CONTINUE

    RETURN
    END
    SUBROUTINE TSUM2(IT,REC,PWT,LCODE,TOURS,STPS,SHIP,TSHIP,RCVD,
*                   TRCVD,SEEMPTY,REEMPTY,ACTITY,GRP,
* SHIPM,TSHIPM,RCVDM,TRCVDM,EMPTYYS,EMPTYR)

    DIMENSION IB(100),IE(100),NSTP(50),STPS(5,50),TOURS(5),
* RC(25,3),MPT(50),TWT(50),SHIP(5,9,20),TSHIP(5,9,20),
* RCVD(5,9,20),TRCVD(5,9,20),SEEMPTY(5,9,20),REEMPTY(5,9,20),
* LCODE(20),STRPS(9,12),RTRPS(9,12),DIST(12),TIME(12),TTS(12),
* SHIPM(3,9,12),TSHIPM(3,9,12),RCVDM(3,9,12),TRCVDM(3,9,12),
* EMPTYYS(3,9,12),EMPTYR(3,9,12),EDIST(12),ETIME(12),ETTS(12),
* PWT(100),TLD(201),TLT(251),DISMX(12),DISMN(12),EMPMX(12),
* EMPMN(12),ETLD(201)

    CHARACTER*150 REC(100)
    CHARACTER*12 ACTITY(9)
    CHARACTER*20 GRP(12)

```

```

        DO 21 IN = 1,12
            DISMX(IN) = 0.
            DISMN(IN) = 99.
            EMPMX(IN) = 0.
            EMPMN(IN) = 99.
21    CONTINUE

C    IT IS NUMBER OF TRIPS FOR A VEHICLE
C    REC CONTAINS THE DATA FOR EACH TRIP
C    ITR IS THE NUMBER OF TOURS MADE BY VEHICLE
C

        REWIND 7

9999 CONTINUE

99999 CONTINUE

C    READ DATA BACK AND BEGIN PROCESS OF SUMING TRIPS LOADS BY VEHICLE CLASS
C    ACTIVITY, AND TYPE OF COMMODITY
C    ISTRT IS POINTER TO INDICATE IF LOOP IS PROCESSING FIRST RECORD FOR VEH
C
        ISTRT = 0

888 CONTINUE

        READ(7,11,END=999) IVC,FLOAD,IWO,IWD,IAO,IAD,IPO,IPD,JCAR,
*   D,T,SHP,RCV,KEMP
11    FORMAT(11X,I3,F8.0,7I3,38X,2F8.2,2F10.1,I5)

        LVC = 3
        IF(IVC.LE.5) LVC = 2
        IF(IVC.LE.2) LVC = 1

        IF(IAO.LE.0.OR.IAO.GT.8) IAO = 9
        IF(IAD.LE.0.OR.IAD.GT.8) IAD = 9

C    FIND SUBSCRIPT FOR TYPE OF COMMODITY

        DO 14 LP = 1,20
            IF(LCODE(LP).EQ.JCAR) GO TO 15
14    CONTINUE
            LP = 19
15    CONTINUE

            IF(LP.EQ.20) THEN
                SHP = 0.
                RCV = 0.
            END IF

            KT = 11
            IF(LP.LE.3) KT = 1
            IF(LP.EQ.5.OR.LP.EQ.6) KT = 3
            IF(LP.EQ.4.OR.LP.EQ.10.OR.LP.EQ.11) KT = 2
            IF(LP.EQ.7.OR.LP.EQ.12) KT = 4
            IF(LP.EQ.8.OR.LP.EQ.9) KT = 5
C            IF(LP.EQ.10.OR.LP.EQ.11) KT = 6

```

```

IF(LP.EQ.13) KT = 6
IF(LP.EQ.14) KT = 7
IF(LP.EQ.15.OR.LP.EQ.16) KT = 8
IF(LP.EQ.17) KT = 10
IF(LP.EQ.18) KT = 9
IF(LP.EQ.19) KT = 11
IF(LP.EQ.20) KT = 12

IF(SHP.EQ.0.0) THEN
  SEMPTY(IVC,IAO,LP) = SEMPTY(IVC,IAO,LP) + 1.0
  STRPS(IAO,KT) = STRPS(IAO,KT) + 1.0
  EMPTYS(LVC,IAO,KT) = EMPTYS(LVC,IAO,KT) + 1.0
END IF

IF(RCV.EQ.0.0) THEN
  REMPTY(IVC,IAD,LP) = REMPTY(IVC,IAD,LP) + 1.0
  RTRPS(IAD,KT) = RTRPS(IAD,KT) + 1.0
  EMPTYR(LVC,IAD,KT) = EMPTYR(LVC,IAD,KT) + 1.0
END IF

IF(SHP.NE.0.0) THEN
  SHIP(IVC,IAO,LP) = SHIP(IVC,IAO,LP) + SHP
  TSHIP(IVC,IAO,LP) = TSHIP(IVC,IAO,LP) + 1.0
  STRPS(IAO,KT) = STRPS(IAO,KT) + 1.0
  SHIPM(LVC,IAO,KT) = SHIPM(LVC,IAO,KT) + SHP
  TSHIPM(LVC,IAO,KT) = TSHIPM(LVC,IAO,KT) + 1.0
END IF

IF(RCV.NE.0.0) THEN
  RCVD(IVC,IAD,LP) = RCVD(IVC,IAD,LP) + RCV
  TRCVD(IVC,IAD,LP) = TRCVD(IVC,IAD,LP) + 1.0
  RTRPS(IAD,KT) = RTRPS(IAD,KT) + 1.0
  RCVDM(LVC,IAD,KT) = RCVDM(LVC,IAD,KT) + RCV
  TRCVDM(LVC,IAD,KT) = TRCVDM(LVC,IAD,KT) + 1.0
END IF

IF(SHP.NE.0.0.OR.RCV.NE.0.0) THEN
  DIST(KT) = DIST(KT) + D
  TIME(KT) = TIME(KT) + T
  TTS(KT) = TTS(KT) + 1.0
  DISMX(KT) = AMAX1(DISMX(KT),D)
  DISMN(KT) = AMIN1(DISMN(KT),D)
  DD = D + 0.5
  IDD = DD
  IF(IDD.LE.0) IDD = 1
  IF(IDD.GT.200) IDD = 201
  TLD(IDD) = TLD(IDD) + 1.0
END IF

IF(SHP.EQ.0.0.AND.RCV.EQ.0.0) THEN
  EDIST(KT) = EDIST(KT) + D
  ETIME(KT) = ETIME(KT) + T
  ETTS(KT) = ETTS(KT) + 1.0
  EMPMX(KT) = AMAX1(EMPMX(KT),D)
  EMPMN(KT) = AMIN1(EMPMN(KT),D)
  ED = D + 0.5
  IED = ED

```

```

        IF(IED.LE.0) IED = 1
        IF(IED.GT.200) IED = 201
        ETLD(IED) = ETLD(IED) + 1.0
    END IF

    GO TO 888

12 CONTINUE

999 CONTINUE

    DO 4 I = 1,9
        S1 = 0.
        S2 = 0.
        WRITE(4,101) ACTITY(I)
101  FORMAT(5X,A12)

    DO 5 J = 1,12
        S1 = S1 + STRPS(I,J)
        S2 = S2 + RTRPS(I,J)
    5 CONTINUE
    DO 3 J = 1,12
        PCT1 = 0.
        PCT2 = 0.
        IF(S1.NE.0.0) PCT1 = STRPS(I,J)/S1*100.
        IF(S2.NE.0.0) PCT2 = RTRPS(I,J)/S2*100.
        WRITE(4,100) GRP(J),STRPS(I,J),PCT1,RTRPS(I,J),PCT2
100  FORMAT(2X,'COMODITY ',A20,' SHIP ',F8.0,' PCT ',F8.3,
        * ' RECEIVE',F8.0,' PCT ',F8.3)
    3 CONTINUE
    4 CONTINUE

    S1 = 0.
    S2 = 0.
    S3 = 0.
    DO 20 I = 1,12
        DAVG = 0.
        TAVG = 0.
        EDAVG = 0.
        ETAVG = 0.
        IF(TTS(I).NE.0.0) THEN
            DAVG = DIST(I)/TTS(I)
            TAVG = TIME(I)/TTS(I)
        END IF
        IF(ETTS(I).NE.0.0) THEN
            EDAVG = EDIST(I)/ETTS(I)
            ETAVG = ETIME(I)/ETTS(I)
        END IF
        WRITE(4,102) GRP(I),TTS(I),DAVG,TAVG,DISMX(I),DISMN(I),ETTS(I),
        * EDAVG,ETAVG,EMPMX(I),EMPMN(I)
102  FORMAT(2X,'COMODITY ',A20,' TRIPS ',F8.0,' AVG DIST ',F8.3,
        * ' AVG TIME ',F8.3,' MAX ',F8.3,' MIN ',F8.3/20X,' EMPTY TRPS ',
        * F8.0,' AVG DIST ',F8.3,
        * ' AVG TIME ',F8.3,' MAX ',F8.3,' MIN ',F8.3)
    20 CONTINUE
    DO 22 I = 1,201
        IF(TLD(I).LE.0.0.AND.ETLD(I).LE.0.0) GO TO 22

```

```

        WRITE(4,23) I, TLD(I), ETLD(I)
23  FORMAT(5X, 'DIST ', I3, 2F10.2)
22 CONTINUE

RETURN
END
SUBROUTINE MTCH(JC, LC, KC)
DIMENSION LC(20)

DO 1 I = 1, 20
  IF(JC.EQ.LC(I)) THEN
    KC = 11
    IF(I.LE.3) KC = 1
    IF(I.EQ.4.OR.I.EQ.10.OR.I.EQ.11) KC = 2
    IF(I.EQ.5.OR.I.EQ.6) KC = 3
    IF(I.EQ.7.OR.I.EQ.12) KC = 4
    IF(I.EQ.8.OR.I.EQ.9) KC = 5
    IF(I.EQ.13) KC = 6
    IF(I.EQ.14) KC = 7
    IF(I.EQ.15.OR.I.EQ.16) KC = 8
    IF(I.EQ.17) KC = 10
    IF(I.EQ.18) KC = 9
    IF(I.EQ.19) KC = 11
    IF(I.EQ.20) KC = 12
    RETURN
  END IF
1 CONTINUE
  KC = 11
  RETURN
END

```

APPENDIX D
INSTRUCTIONS AND GISDK MACROS FOR
CREATING TRIPCAL5 INPUT DATA

COM_PREP_1 OPERATING INSTRUCTIONS

There are 5 Data set name boxes which must be filled. The first 2 are input data sets and the last 3 are output data sets. The input data sets are:

- (1) DA1 data file
- (2) EA data file

The output data files are:

- (3) Output Listing File
- (4) Output PCR data
- (5) Output DA data

The expected file extension for the DA1 and EA data files is “ASC” or “TXT” but any file extension is accepted for the DA1 and EA data sets.

The Output listing file will be given a file extension of “LST”.

The PCR and DA data files will be given a file extension of “TXT”.

The DA1 data must have data for zones 1 to the maximum zone in the DA1 data records. DA must be in upper case in columns 1 and 2 for the DA1 records to be recognized. Other record types are skipped.

The EA data must define area types between 1 and 6 for all zones between 1 and the maximum zone in the DA1 data.

The Heading Field is written to the first line of the listing file. If this field is not set it is blanks. This field is optional.

```

MACRO "COM_PREP_1"
Global ptr_d,dal_name_d,sgz_name,com_build_dal_name
RunDbox("com_23_BOX1")
endmacro

Macro "com_prep_1"
RunMacro("COM_PREP_1")
endmacro

DIALOG "com_23_BOX1" title: "Build PCR, DA2, DA3, and DA$ records from DA1 and
EA "
init do
    global com_build_dal_name, com_build_EA_name, com_build_list_name,
com_build_header
    global Fill_Year_d,TAZfld_d, fldnames_d, com_build_pcr_name,
com_build_da_name
    com_build_dal_name = "nul"
    com_build_EA_name = "nul"
    com_build_list_name = "nul"
    com_build_pcr_name = "nul"
    com_build_da_name = "nul"
    com_build_header = " "
    Fill_Year_d = 9999
    lyrs = GetLayerNames()
enditem

//
// ++++++
// DA1 name
// ++++++
Text "DA1 data file" 6,1
Checkbox 2.5,2.5 variable:chkdal
do if chkdal=1 then do
    com_build_dal_name = ChooseFile({"Data *.asc", "*.txt"}),
"Choose DA1 File",Null)
end
if chkdal=0 then do
    com_build_dal_name="nul"
end
enditem
text "fcnamin" 6,2.5,60
Framed
variable: com_build_dal_name

//
// ++++++
// EA name
// ++++++
//
Text "EA data file " 6,4
Checkbox 2.5,5.5 variable:chksgz

```

```

do if chksgz=1 then do
  com_build_EA_name = ChooseFile({"Data *.asc", "*.txt"}},
"Choose a EA File",Null)
end
if chksgz=0 then do
  com_build_EA_name="nul"
end
enditem
text "fcnaminat" 6,5.5,60
  Framed
  variable: com_build_EA_name

//
// ++++++
// List name
// ++++++
Text "Output Listing File " 6,7
Checkbox 2.5,8.5 variable:chklst
do if chkfst=1 then do
  com_build_list_name = ChooseFileName({"List File", "*.lst"}},
"Save the List File as",Null)
end
if chkfst=0 then do
  com_build_list_name="nul"
end
enditem
text "fcnaminat" 6,8.5,60
  Framed
  variable: com_build_list_name

//
// ++++++
// PCR name
// ++++++
Text "Output PCR Data " 6,10
Checkbox 2.5,11.5 variable:pcrout
do if pcrout=1 then do
  com_build_pcr_name = ChooseFileName({"PCR Data File",
"*.txt"}}, "Save the PCR Data as",Null)
end
if pcrout=0 then do
  com_build_pcr_name="nul"
end
enditem
text "fcnaminat" 6,11.5,60
  Framed
  variable: com_build_pcr_name

//
// ++++++
// DA2-4 name
// ++++++
Text "Output DA Data " 6,13
Checkbox 2.5,14.5 variable:daout

```

```

do if daout=1 then do
    com_build_da_name = ChooseFileName({"DA2-4 Data File",
    "*.txt"}}, "Save the DA2-4 Data as",Null)
end
if daout=0 then do
    com_build_da_name="nul"
end
enditem
text "fcnaminat" 6,14.5,60
    Framed
    variable: com_build_da_name

Text "Heading" 6,20
Edit text "header_B" 6,21.5,60
    variable: com_build_header

button "Cancel" 29,28.5,10 do
    Return()
enditem

button "OK" 32,30.5,4 do

then do
    if com_build_da1_name = "nul" or Len(com_build_da1_name) < 3
        ShowMessage(" Choose a DA1 data file name.")
        goto skipOK
    end

then do
    if com_build_EA_name = "nul" or Len(com_build_EA_name) < 3
        ShowMessage(" Choose a EA data file name.")
        goto skipOK
    end

3 then do
    if com_build_list_name = "nul" or Len(com_build_list_name) <
        ShowMessage(" Choose a Listing file name.")
        goto skipOK
    end

then do
    if com_build_pcr_name = "nul" or Len(com_build_pcr_name) < 3
        ShowMessage(" Choose a PCR file name.")
        goto skipOK
    end

then do
    if com_build_da_name = "nul" or Len(com_build_da_name) < 3
        ShowMessage(" Choose a DA2-4 Data File name.")
        goto skipOK
    end

    RunMacro("com_23")
    Return()

```

```

skipOK:
        enditem

endddbox

Macro "com_23"
    HideDbox("com_23_BOX1")
        nbar = 0
        mb = 0
        ptral_r=OpenFile(com_build_da1_name,"r") // check length of
first record
        mxz = 0

        ptral_r=OpenFile(com_build_da1_name,"r") // check length of first
record
        mxzn = -1
        nrr = 0
        on EndOfFile goto EndDA1
        for j=1 to 999999 do
            recdal = ReadLine(ptral_r)
            if Substring(recdal,1,3) = "DA1" then do
                jz = S2i(Substring(recdal,4,5))
                mxzn = Max(mxzn,jz)
            end
        end
EndDA1:
        mxrec = j - 1
//        ShowMessage("Number of records = "+R2s(mxrec))
//        ShowMessage("Maximum zone number = "+R2s(mxzn))
        CloseFile(ptral_r)

        ptral_r=OpenFile(com_build_da1_name,"r") // Read DA1 data

        mxzn = R2i(mxzn)
        Dim hh[mxzn],basic[mxzn],retail[mxzn],service[mxzn]

        on EndOfFile goto EndDA1b

        EnableProgressBar("com_23",10)
        CreateProgressBar("Read DA1 Records", "True")
        nbar = nbar + 1

        for j=1 to mxrec do
            recdal = ReadLine(ptral_r)
            perc=r2i((j/mxzn)*100)
            stat=UpdateProgressBar("Read DA1 Records",perc)

            jz = S2i(Substring(recdal,4,5))
            if jz > 0 and jz <= mxzn then do
                hh[jz] = S2r(Substring(recdal,23,7))
                basic[jz] = S2r(Substring(recdal,51,7))
            end
        end

```

```

        retail[jz] = S2r(Substring(recda1,58,7))
        service[jz] = S2r(Substring(recda1,65,7))
    end
end
EndDA1b:
mxrec = j - 1
CloseFile(ptral_r)

// read the EA data and build the AT area type array
Dim at[mxzn]
for j=1 to mxzn do
    at[j] = -1
end

ptrea_r=OpenFile(com_build_EA_name,"r") // Read EA data
on EndOfFile goto EndEA
Dim atc[16]
for j=1 to 16 do
    atc[j] = 0
end

CreateProgressBar("Read EA Records", "True")
nbar = nbar + 1
nea = 0

for j=1 to 999999 do
    perc=r2i((nea/mxzn)*100)
    stat=UpdateProgressBar("Read EA Records",perc)
    recea = ReadLine(ptrea_r)

    if Substring(recea,1,3) = "EA " then do
        atc[1] = S2i(Substring(recea,3,3))
        cl = 6
        for k=2 to 16 do
            atc[k] = S2i(Substring(recea,cl,5))
            cl = cl + 5
        end

        jskp = 0
        for k=2 to 16 do
            if(jskp = 1) then do
                jskp = 0
                goto end_for_k
            end

            if(atc[k] = 0) then goto return_k
            if(k <= 15) then do
                if(atc[k] > 0 and atc[k+1] < 1) then do
                    if(atc[k] < abs(atc[k+1])) then do
                        ls = atc[k]
                        lex = abs(atc[k+1])
                        for m=ls to lex do
                            at[m] = atc[1]
                        end
                    end
                end
            end
        end
    end
end

```

```

        nea = nea + 1
    end
    jskip = 1
    goto end_for_k
end
end
end

if(atc[k] > 0) then do
    m = atc[k]
    at[m] = atc[1]
    nea = nea + 1
    jskip = 0
    goto end_for_k
end
end_for_k:
end
return_k:
    perc=r2i((nea/mxzn)*100)
    stat=UpdateProgressBar("Read EA Records",perc)

//          ShowArray(at)

    end
end

```

EndEA:

```

ptr_lst = OpenFile(com_build_list_name,"w")
WriteLine(ptr_lst,com_build_header)
WriteLine(ptr_lst," ")
WriteLine(ptr_lst," DA1 Input File      = "+com_build_da1_name)
WriteLine(ptr_lst," EA Input File      = "+com_build_EA_name)
WriteLine(ptr_lst," ")
WriteLine(ptr_lst," PCR Output file   = "+com_build_pcr_name)
WriteLine(ptr_lst," DA2-4 Output file = "+com_build_da_name)

nea = j-1
mxaz = -1
nt = 0
// LOOK FOR MISSING ZONES IN THE DA1 DATA
nms = 0
for j=1 to mxzn do
    if(hh[j] < 0.0) then nms = nms + 1
end
if(nms > 0) then do
    nrr = nrr + 1
    WriteLine(ptr_lst," Error missing da1 data for "+R2s(cme)+" zones")
end

for j=1 to mxzn do
    if(at[j] > 0) then do
        mxaz = j
        nt = nt + 1
    end
end

```

```

        end
    end
    WriteLine(ptr_lst," Maximum Areatype zone = "+R2S(mxaz))
    WriteLine(ptr_lst,"      number of AT zones = "+R2S(nt))
    WriteLine(ptr_lst,"                EA records = "+R2S(nea))

//
//      WRITE(6,219) (J,(AT(L),L=J,MIN(J+24,MXAZ)),J=1,MXAZ,25)
// 219 FORMAT(' AT(',I4,') =',1X,25I3)
//      for j=1 to mxaz step 25 do
//          ln = " AT["+Lpad(R2S(j),4)+"] ="
//          for k=j to Min(j+24,mxaz) do
//              ln = ln + " "+R2s(at[k])
//          end
//          WriteLine(ptr_lst,ln)
//      end

// Report missing area type zones
    if(mxaz <> nt) or (mxaz <> mxzn) then do
        lines = 0
//      SUBROUTINE OUTEQ(mxzn,-1,at)
        DIM z[7]
        for j=1 to 7 do
            z[j] = -1
        end
//C LOOK FOR SECTORS 1 TO M
        lns = 0
        is = -1
// 100 format('1''0''0table e2',t50,'Zones missing in EA records'/lx)
        g = 0
//c beginning of loop to find a zone equated to sector is
        j = 0
outeq03:
        j = j + 1
        if(j > mxzn) then goto outeq04
        if(at[j] <> is) then goto outeq03
//c search for a range
        j2 = j + 1
        for k = j2 to mxzn do
            if(at[k] <> is) then goto outeq06
outeq05:
        end
        k = mxzn + 1
outeq06:
        if(k-1 > j) then goto outeq61
//c insert single zone
        if(g <= 6) then goto outeq08
        lns = lns + 1
        if(Mod(lns,50) = 1) then WriteLine(ptr_lst," Zones Missing in EA
Records")
        ln = " "
        for i=1 to g do
            ln = ln + Lpad(Format(z[i],"*0"),7)
        end
        WriteLine(ptr_lst,ln)
        g = 0

```



```

outeq08:
    z[g+1] = j
    g = g + 1
    j = j + 1
    goto outeq03
//c insert range of zones
outeq61:
    if(g <= 5) then goto outeq07
    lns = lns + 1
    if(Mod(lns,50) = 1) then WriteLine(ptr_lst," Zones Missing in EA
Records")
    ln = " "
    for i=1 to g do
        ln = ln + Lpad(Format(z[i],"*0"),7)
    end
    WriteLine(ptr_lst,ln)
    g = 0
outeq07:
    z[g+1] = j
    z[g+2] = -(k - 1)
//c check if range of 2, if so make into 2 zones
    if(z[g+2]+1 = -z[g+1]) then z[g+2] = -z[g+2]
    g = g + 2
    j = k
    goto outeq03
outeq04:
    if(g = 0) then goto outeq02
    lns = lns + 1
    if(Mod(lns,50) = 1) then WriteLine(ptr_lst," Zones Missing in EA
Records")
    ln = " "
    for i=1 to g do
        ln = ln + Lpad(Format(z[i],"*0"),7)
    end
    g = 0
    WriteLine(ptr_lst,ln)
outeq02:
    if g > 0 then do
        if(Mod(lns,50) = 1) then WriteLine(ptr_lst," Zones Missing in EA
Records")
        ln = " "
        for i=1 to g do
            ln = ln + Lpad(Format(z[i],"*0"),7)
        end
        WriteLine(ptr_lst,ln)
        g = 0
    end
    end

    if(mxaz <> nt) then do
        nrr = nrr + 1
        mis_ea = mxaz - nt
        WriteLine(ptr_lst," Error Missing "+R2s(mis_ea)+
            " zones in the area type table of equals")
    end
    if(mxaz <> mxzn) then do
        nrr = nrr + 1

```

```

        WriteLine(ptr_lst," Error DA1 number of zones = "+Lpad(R2s(mxzn),6)
            +" and EA last zone = "+Lpad(R2s(mxaz),6)+" are different")
    end
    if(nrr > 0) then do
        WriteLine(ptr_lst," Quitting for errors in DA1 and EA data")
        goto normal_end
    end
// C SUM DATA FOR PCR RECORDS
//
Dim atfrq[25]
Dim hh_ea[25],bas_ea[25],ret_ea[25],serv_ea[25],tot_z[25]
for j=1 to 25 do
    atfrq[j] = 0
    hh_ea[j] = 0
    bas_ea[j] = 0
    ret_ea[j] = 0
    serv_ea[j] = 0
    tot_z[j] = 0
end

for j=1 to mxzn do
    tothh = tothh + hh[j]
    lat = at[j]
    if(lat < 1 or lat > 25) then do
        nrr = nrr + 1
        WriteLine(ptr_lst," error area type for zone "+Lpad(R2s(j),6)+
            " is "+Lpad(R2s(lat),3))

        goto end_do2_j
    end
    atfrq[lat] = atfrq[lat] + 1
    hh_ea[lat] = hh_ea[lat] + hh[j]
    bas_ea[lat] = bas_ea[lat] + basic[j]
    ret_ea[lat] = ret_ea[lat] + retail[j]
    serv_ea[lat] = serv_ea[lat] + service[j]
    tot_z[lat] = tot_z[lat] + hh[j] + basic[j] + retail[j] +
service[j]
end_do2_j:
    end
//     WriteLine(ptr_lst," HH_EA")
//     ln = " "
//     for j=1 to 10 do
//         jhh = hh_ea[j]
//         chh = R2s(jhh)
//         chh10 = Lpad(chh,10)
//         ln = ln + chh10 //Lpad(R2s(hh_ea[j]),10)
//     end
//     WriteLine(ptr_lst,ln)
//     ln = " "
//     for j=11 to 20 do
//         ln = ln + Lpad(R2s(hh_ea[j]),10)
//     end
//     WriteLine(ptr_lst,ln)
//     ln = " "
//     for j=20 to 25 do
//         ln = ln + Lpad(R2s(hh_ea[j]),10)
//     end
end

```

```

//      WriteLine(ptr_lst,ln)

//      WRITE(6,300) 'BAS_EA',BAS_EA
//      WriteLine(ptr_lst," bas_ea")
//      ln = " "
//      for j=1 to 10 do
//          ln = ln + Lpad(R2s(bas_ea[j]),10)
//      end
//      WriteLine(ptr_lst,ln)
//      ln = " "
//      for j=11 to 20 do
//          ln = ln + Lpad(R2s(bas_ea[j]),10)
//      end
//      WriteLine(ptr_lst,ln)
//      ln = " "
//      for j=20 to 25 do
//          ln = ln + Lpad(R2s(bas_ea[j]),10)
//      end
//      WriteLine(ptr_lst,ln)

//      WRITE(6,300) 'RET_EA',RET_EA
//      WriteLine(ptr_lst," ret_ea")
//      ln = " "
//      for j=1 to 10 do
//          ln = ln + Lpad(R2s(ret_ea[j]),10)
//      end
//      WriteLine(ptr_lst,ln)
//      ln = " "
//      for j=11 to 20 do
//          ln = ln + Lpad(R2s(ret_ea[j]),10)
//      end
//      WriteLine(ptr_lst,ln)
//      ln = " "
//      for j=20 to 25 do
//          ln = ln + Lpad(R2s(ret_ea[j]),10)
//      end
//      WriteLine(ptr_lst,ln)

//      WRITE(6,300) 'SERV_EA',SERV_EA
//      WriteLine(ptr_lst," serv_ea")
//      ln = " "
//      for j=1 to 10 do
//          ln = ln + Lpad(R2s(serv_ea[j]),10)
//      end
//      WriteLine(ptr_lst,ln)
//      ln = " "
//      for j=11 to 20 do
//          ln = ln + Lpad(R2s(serv_ea[j]),10)
//      end
//      WriteLine(ptr_lst,ln)
//      ln = " "
//      for j=20 to 25 do
//          ln = ln + Lpad(R2s(serv_ea[j]),10)
//      end
//      WriteLine(ptr_lst,ln)

```

```

//      WRITE(6,300) 'TOT_Z',TOT_Z
//      WriteLine(ptr_lst," tot_z")
//      ln = " "
//      for j=1 to 10 do
//          ln = ln + Lpad(R2s(tot_z[j]),10)
//      end
//      WriteLine(ptr_lst,ln)
//      ln = " "
//      for j=11 to 20 do
//          ln = ln + Lpad(R2s(tot_z[j]),10)
//      end
//      WriteLine(ptr_lst,ln)
//      ln = " "
//      for j=20 to 25 do
//          ln = ln + Lpad(R2s(tot_z[j]),10)
//      end
//      WriteLine(ptr_lst,ln)
//      WRITE(6,305) 'ATFRQ',ATFRQ
//      WriteLine(ptr_lst," atfrq")
//      ln = " "
//      for j=1 to 10 do
//          ln = ln + Lpad(R2s(atfrq[j]),10)
//      end
//      WriteLine(ptr_lst,ln)
//      ln = " "
//      for j=11 to 20 do
//          ln = ln + Lpad(R2s(atfrq[j]),10)
//      end
//      WriteLine(ptr_lst,ln)
//      ln = " "
//      for j=20 to 25 do
//          ln = ln + Lpad(R2s(atfrq[j]),10)
//      end
//      WriteLine(ptr_lst,ln)

// C CHECK IF MORE THAN 6 AREA TYPES
mxat = 0
for j=1 to 24 do
    if(atfrq[j] > 0) then mxat = j
end
if(mxat > 6) then do
    nrr = nrr + 1
    writeLine(ptr_lst," Error more than 6 area types, can't generate pcr
records")
    WriteLine(ptr_lst," Area Type Counts :")
    for j=1 to 25 step 10 do
        ln = " "
        jx = Min(j + 9,25)
        for k=j to jx do
            ln = ln + Lpad(R2s(atfrq(j)),10)
        end
        WriteLine(ptr_lst,ln)
    end
end
end

```

```

        if(nrr > 0) then do
            WriteLine(ptr_lst," quitting because of ",Lpad(R2s(nrr),5)+"
errors")
            goto normal_end
        end
// C BUILD PCR RECORDS AND WRITE
    ptr_pcr = OpenFile(com_build_pcr_name,"w")
//    PCT = 0.0
    Dim pct[4],cpct5[4]
    for j=1 to 4 do
        Dim pct6[6],cpct5x[6]
        pct[j] = pct6
        cpct5[j] = cpct5x
        for k=1 to 6 do
            pct[j][k] = 0
            cpct5[j][k] = " -0.0 "
        end
    end
    end
    totz = 0.0
    for j=1 to mxzn do
        totz = totz + hh[j] + basic[j] + retail[j] + service[j]
    end
// debug totz
    totz2 = 0.0
    for j=1 to 6 do
        totz2 = totz2 + hh_ea[j] + bas_ea[j] + ret_ea[j] + serv_ea[j]
    end
    if Abs(totz - totz2) > 0.01 then do
        WriteLine(ptr_lst," Error Abs(totz -totz2) > 0.01: = "+R2s(Abs(totz
- totz2)))
        nrr = nrr + 1
    end
    z = 0.0
    if(totz> 0.0 ) then z = 100./totz
    for j=1 to 6 do
        pct[1][j] = z*hh_ea[j]
        pct[2][j] = z*bas_ea[j]
        pct[3][j] = z*ret_ea[j]
        pct[4][j] = z*serv_ea[j]
    end

//    WRITE(*,*) ' TOTZ = ',TOTZ,' Z = ',Z

//    for j=1 to 6 do
//        for k=1 to 4 do
//            cpctx = Right(Format(pct[k][j],".0000"),5)
//            cpct5[k][j] = cpctx
//            if(pct[k][j] > 1.0) then
//                cpctx = Lpad(Format(pct[k][j],".00"),5)
//                cpct5[k][j] = cpctx
//                if cpct5[k][j] = " " then cpct5[k][j] = R2s(pct[k][j])
//                if cpct5[k][j] = null then cpct5[k][j] = R2s(pct[k][j])
//            end
//        end
//    end

    for j=1 to 6 do
        for k=1 to 4 do

```

```

        cpctx = Lpad(Format(pct[k][j],"*0.0"),5)
        if pct[k][j] < 9.994 then cpctx =
Lpad(Format(pct[k][j],"*0.00"),5)
        if pct[k][j] < 0.9994 then cpctx =
Lpad(Format(pct[k][j],"*0.000"),5)
        if Substring(cpctx,1,2) = "0." then cpctx = "
"+Substring(cpctx,2,4)
        cpct5[k][j] = cpctx
    end
end

WriteLine(ptr_pcr,"PCR 1
1"+cpct5[1][1]+cpct5[1][2]+cpct5[1][3]+cpct5[1][4]+cpct5[1][5]+cpct5[1][6])
WriteLine(ptr_pcr,"PCR 1
2"+cpct5[2][1]+cpct5[2][2]+cpct5[2][3]+cpct5[2][4]+cpct5[2][5]+cpct5[2][6])
WriteLine(ptr_pcr,"PCR 1
3"+cpct5[3][1]+cpct5[3][2]+cpct5[3][3]+cpct5[3][4]+cpct5[3][5]+cpct5[3][6])
WriteLine(ptr_pcr,"PCR 1
4"+cpct5[4][1]+cpct5[4][2]+cpct5[4][3]+cpct5[4][4]+cpct5[4][5]+cpct5[4][6])

ptr_da = OpenFile(com_build_da_name,"w")
// C WRITE DA2 DATA
CreateProgressBar("Write DA2 Records", "True")
nbar = nbar + 1

for j=1 to mxzn do
tz = hh[j] + basic[j] + retail[j] + service[j]
ln = "DA2"+Lpad(Format(j,"*0"),5)+Lpad(Format(tz,"*.0"),9)
WriteLine(ptr_da,ln)
perc=r2i((j/mxzn)*100)
stat=UpdateProgressBar("Write DA2 Records",perc)
end
// c write da3 records
Dim p100[6]
p100[1] = " 100.  0.  0.  0.  0.  0."
p100[2] = "   0. 100.  0.  0.  0.  0."
p100[3] = "   0.  0. 100.  0.  0.  0."
p100[4] = "   0.  0.  0. 100.  0.  0."
p100[5] = "   0.  0.  0.  0. 100.  0."
p100[6] = "   0.  0.  0.  0.  0. 100."

CreateProgressBar("Write DA3 Records", "True")
nbar = nbar + 1
for j=1 to mxzn do
lat = at[j]
if(lat >= 1 and lat <= 6) then do
ln = "DA3"+Lpad(Format(j,"*0"),5)+p100[lat]
WriteLine(ptr_da,ln)
perc=r2i((j/mxzn)*100)
stat=UpdateProgressBar("Write DA3 Records",perc)
end
end

// C WRITE DA4 RECORDS
CreateProgressBar("Write DA4 Records", "True")
nbar = nbar + 1

```

```

for j=1 to mxzn do
  tz = hh[j] + basic[j] + retail[j] + service[j]
  fpct = 0.0
  if(tz > 0.0) then fpct = 100.0/tz
  da4 = "DA4"+Lpad(Format(j,"*0"),5)
  da4 = da4+Lpad(Format(fpct*hh[j],"*0.0"),5)
  da4 = da4+Lpad(Format(fpct*basic[j],"*0.0"),5)
  da4 = da4+Lpad(Format(fpct*retail[j],"*0.0"),5)
  da4 = da4+Lpad(Format(fpct*service[j],"*0.0"),5)
  WriteLine(ptr_da,da4)
  perc=r2i((j/mxzn)*100)
  stat=UpdateProgressBar("Write DA4 Records",perc)
end

normal_end:
  if nrr = 0 then ShowMessage("Processed "+R2s(mxzn)+" zones without
errors.")
  if nrr <> 0 then ShowMessage(R2s(nrr)+" Errors ocured.")

  if nbar > 0 then do
    for j=1 to nbar do
      destroyprogressbar()
    end
  end
  Return()

// Trap some other Transcad errors
on Error goto error_end
on NotFound goto error_end
on Escape goto error_end
on NonUnique goto error_end
on Missing goto error_end
on DivideByZero goto error_end
on EndOfFile goto error_end
// on Locked goto error_end
on LanguageError goto error_end

error_end:
  last_err = GetLastError()
  ShowMessage(last_err)
  goto normal_end

EndMacro

```


**APPENDIX E:
GISDK MACROS FOR
HGA CRITICAL LINK ANALYSIS**

GISDK BATCH MACRO FOR RUNNING CLA BY COMMODITY GROUP AND BY CRITICAL SET TABLE, AND THEN COMBINING CRITICAL MATRICES

C1. For Running the CLA

GISDK Document Filename: HGAC_CLA_9comm_ins_outs &Total_ins_outs

Macro "Batch Macro"

RunMacro("TCB Init")

// STEP 1: Assignment [ins_AG]

```
Opts = {{ "Input",  {"Database",      "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},
              {"Network",      "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},
              {"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\9_Commodity.mtx",
              "AG",
              "Row Index",
              "Column Index"}},
              {"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_ins_AG.DBF"} }},
{"Field",  {"FF Time",      "Time"}},
{"Global", {"Load Method",      1},
              {"Critical Link Flows", { 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15,
              16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
              31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 } }},
{"Output", {"Flow Table",  "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_ins_Total.bin"},
              {"Critical Matrix", {"Label",
              "Critical Matrix"},
              {"File Name",
              "C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_ins_AG.mtx"} } } }
```

if !RunMacro("TCB Run Procedure", 1, "Assignment", Opts) then goto quit

// STEP 2: Assignment [ins_BM]

```
Opts = {{ "Input",  {"Database",      "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},
              {"Network",      "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},
              {"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\9_Commodity.mtx",
              "BM",
              "Row Index",
              "Column Index"}},
```

```

        {"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_ins_BM.DBF"}}},
{"Field", {"FF Time", "Time"}},
{"Global", {"Load Method", 1},
        {"Critical Link Flows", {1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,
                                16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
                                31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 }}}},
{"Output", {"Flow Table", "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_ins_Total.bin"},
        {"Critical Matrix", {"Label",
                              "Critical Matrix",
                              "File Name",
                              "C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_ins_BM.mtx"}}}}

```

if !RunMacro("TCB Run Procedure", 2, "Assignment", Opts) then goto quit

// STEP 3: Assignment [ins_CP]

```

Opts = {"Input", {"Database", "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},
        {"Network", "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},
        {"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\9_Commodity.mtx",
                                "CP",
                                "Row Index",
                                "Column Index"}},
        {"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_ins_CP.DBF"}}},
{"Field", {"FF Time", "Time"}},
{"Global", {"Load Method", 1},
        {"Critical Link Flows", {1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,
                                16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
                                31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 }}}},
{"Output", {"Flow Table", "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_ins_Total.bin"},
        {"Critical Matrix", {"Label",
                              "Critical Matrix",
                              "File Name",
                              "C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_ins_CP.mtx"}}}}

```

if !RunMacro("TCB Run Procedure", 3, "Assignment", Opts) then goto quit

// STEP 4: Assignment [ins_FD]

```

Opts = {"Input", {"Database", "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},
        {"Network", "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},

```

```

{"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\9_Commodity.mtx",
                        "FD",
                        "Row Index",
                        "Column Index"}},
{"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_ins_FD.DBF"}},
{"Field", {"FF Time", "Time"}},
{"Global", {"Load Method", 1},
{"Critical Link Flows", { 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,
                        16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
                        31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 }}}},

{"Output", {"Flow Table", "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_ins_Total.bin"},
{"Critical Matrix", {"Label",
                    "Critical Matrix"},
{"File Name",
"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_ins_FD.mtx"}}}}}

```

if !RunMacro("TCB Run Procedure", 4, "Assignment", Opts) then goto quit

// STEP 5: Assignment [ins_MA]

```

Opts = {"Input", {"Database", "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},
        {"Network", "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},
        {"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\9_Commodity.mtx",
                                "MA",
                                "Row Index",
                                "Column Index"}},
        {"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_ins_MA.DBF"}},
        {"Field", {"FF Time", "Time"}},
        {"Global", {"Load Method", 1},
        {"Critical Link Flows", { 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,
                                16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
                                31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 }}}},
        {"Output", {"Flow Table", "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_ins_Total.bin"},
        {"Critical Matrix", {"Label",
                            "Critical Matrix"},
        {"File Name",
"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_ins_MA.mtx"}}}}}

```

if !RunMacro("TCB Run Procedure", 5, "Assignment", Opts) then goto quit

```
// STEP 6: Assignment [ins_RM]
Opts = {{ "Input",  {"Database",      "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},
            {"Network",      "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},
            {"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\9_Commodity.mtx",
                                     "RM",
                                     "Row Index",
                                     "Column Index"}},
            {"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_ins_RM.DBF"}},
            {"Field",  {"FF Time",      "Time"}},
            {"Global", {"Load Method",   1},
            {"Critical Link Flows", { 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15,
                                     16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
                                     31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 }},
            {"Output", {"Flow Table",    "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_ins_Total.bin"},
            {"Critical Matrix",  {"Label",
                                   "Critical Matrix"},
            {"File Name",
            "C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_ins_RM.mtx"}}}}

if !RunMacro("TCB Run Procedure", 6, "Assignment", Opts) then goto quit
```

```
// STEP 7: Assignment [ins_SE]
Opts = {{ "Input",  {"Database",      "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},
            {"Network",      "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},
            {"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\9_Commodity.mtx",
                                     "SE",
                                     "Row Index",
                                     "Column Index"}},
            {"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_ins_SE.DBF"}},
            {"Field",  {"FF Time",      "Time"}},
            {"Global", {"Load Method",   1},
            {"Critical Link Flows", { 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15,
                                     16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
                                     31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 }},
            {"Output", {"Flow Table",    "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_ins_Total.bin"},
            {"Critical Matrix",  {"Label",
                                   "Critical Matrix"},
```

```
    {"File Name",  
     "C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_ins_SE.mtx"}}}}}
```

```
if !RunMacro("TCB Run Procedure", 7, "Assignment", Opts) then goto quit
```

```
// STEP 8: Assignment [ins_TX]
```

```
Opts = {{ "Input",  {"Database",      "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},  
             {"Network",      "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},  
             {"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\9_Commodity.mtx",  
                                     "TX",  
                                     "Row Index",  
                                     "Column Index"}},  
             {"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_ins_TX.DBF"}}}},  
 {"Field",  {"FF Time",      "Time"}},  
 {"Global", {"Load Method",   1},  
           {"Critical Link Flows", { 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15,  
                                     16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,  
                                     31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 }}}},  
 {"Output", {"Flow Table",     "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_ins_Total.bin"},  
            {"Critical Matrix", {"Label",  
                                 "Critical Matrix",  
                                 "File Name",  
                                 "C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_ins_TX.mtx"}}}}}
```

```
if !RunMacro("TCB Run Procedure", 8, "Assignment", Opts) then goto quit
```

```
// STEP 9: Assignment [ins_WD]
```

```
Opts = {{ "Input",  {"Database",      "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},  
             {"Network",      "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},  
             {"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\9_Commodity.mtx",  
                                     "WD",  
                                     "Row Index",  
                                     "Column Index"}},  
             {"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_ins_WD.DBF"}}}},  
 {"Field",  {"FF Time",      "Time"}},  
 {"Global", {"Load Method",   1},  
           {"Critical Link Flows", { 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15,  
                                     16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
```

```
31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 } } } },
{"Output", { {"Flow Table", "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_ins_Total.bin"},
{"Critical Matrix", {"Label",
"Critical Matrix"},
{"File Name",
"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_ins_WD.mtx"} } } } }
```

```
if !RunMacro("TCB Run Procedure", 9, "Assignment", Opts) then goto quit
```

```
// STEP 10: Assignment [outs_AG]
```

```
Opts = { {"Input", { {"Database", "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},
{"Network", "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},
{"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\9_Commodity.mtx",
"AG",
"Row Index",
"Column Index"} } },
{"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_outs_AG.DBF"} } } },
{"Field", { {"FF Time", "Time"} } },
{"Global", { {"Load Method", 1},
{"Critical Link Flows", { 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,
16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 } } } },
{"Output", { {"Flow Table", "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_outs_Total.bin"},
{"Critical Matrix", {"Label",
"Critical Matrix"},
{"File Name",
"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_outs_AG.mtx"} } } } }
```

```
if !RunMacro("TCB Run Procedure", 10, "Assignment", Opts) then goto quit
```

```
// STEP 11: Assignment [outs_BM]
```

```
Opts = { {"Input", { {"Database", "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},
{"Network", "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},
{"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\9_Commodity.mtx",
"BM",
"Row Index",
"Column Index"} } },
{"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_outs_BM.DBF"} } } },
```



```

{"Field",  {"FF Time",      "Time"}},
{"Global", {"Load Method",   1},
          {"Critical Link Flows", { 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15,
                                   16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
                                   31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 } }},

{"Output", {"Flow Table",    "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_outs_Total.bin"},
          {"Critical Matrix", {"Label",
                               "Critical Matrix"},
          {"File Name",
          "C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_outs_BM.mtx"} } } }

```

```

if !RunMacro("TCB Run Procedure", 11, "Assignment", Opts) then goto quit

```

```

// STEP 12: Assignment [outs_CP]

```

```

Opts = {"Input",  {"Database",    "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},
        {"Network",    "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},
        {"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\9_Commodity.mtx",
                                   "CP",
                                   "Row Index",
                                   "Column Index"}},
        {"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_outs_CP.DBF"} } } },
{"Field",  {"FF Time",      "Time"}},
{"Global", {"Load Method",   1},
          {"Critical Link Flows", { 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15,
                                   16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
                                   31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 } }},

{"Output", {"Flow Table",    "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_outs_Total.bin"},
          {"Critical Matrix", {"Label",
                               "Critical Matrix"},
          {"File Name",
          "C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_outs_CP.mtx"} } } }

```

```

if !RunMacro("TCB Run Procedure", 12, "Assignment", Opts) then goto quit

```

```

// STEP 13: Assignment [outs_FD]

```

```

Opts = {"Input",  {"Database",    "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},

```

```

{"Network",      "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},
{"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\9_Commodity.mtx",
                        "FD",
                        "Row Index",
                        "Column Index"}},
{"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_outs_FD.DBF"}},
{"Field",  {"FF Time",      "Time"}},
{"Global", {"Load Method",    1},
{"Critical Link Flows", { 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15,
                        16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
                        31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 }}}},

{"Output", {"Flow Table",      "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_outs_Total.bin"},
{"Critical Matrix",  {"Label",
                     "Critical Matrix"},
{"File Name",
"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_outs_FD.mtx"}}}}}

```

if !RunMacro("TCB Run Procedure", 13, "Assignment", Opts) then goto quit

// STEP 14: Assignment [outs_MA]

```

Opts = {"Input",  {"Database",      "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},
{"Network",      "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},
{"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\9_Commodity.mtx",
                        "MA",
                        "Row Index",
                        "Column Index"}},
{"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_outs_MA.DBF"}},
{"Field",  {"FF Time",      "Time"}},
{"Global", {"Load Method",    1},
{"Critical Link Flows", { 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15,
                        16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
                        31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 }}}},

{"Output", {"Flow Table",      "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_outs_Total.bin"},
{"Critical Matrix",  {"Label",
                     "Critical Matrix"},
{"File Name",
"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_outs_MA.mtx"}}}}}

```

```
if !RunMacro("TCB Run Procedure", 14, "Assignment", Opts) then goto quit
```

```
// STEP 15: Assignment [outs_RM]
```

```
Opts = {{ "Input",  {"Database",      "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},
            {"Network",      "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},
            {"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\9_Commodity.mtx",
                                     "RM",
                                     "Row Index",
                                     "Column Index"}},
            {"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_outs_RM.DBF"}},
            {"Field",  {"FF Time",      "Time"}},
            {"Global", {"Load Method",    1},
            {"Critical Link Flows", { 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15,
                                     16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
                                     31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 }}}},

            {"Output", {"Flow Table",      "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_outs_Total.bin"},
            {"Critical Matrix",  {"Label",
                                   "Critical Matrix"},
            {"File Name",
            "C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_outs_RM.mtx"}}}}}
```

```
if !RunMacro("TCB Run Procedure", 15, "Assignment", Opts) then goto quit
```

```
// STEP 16: Assignment [outs_SE]
```

```
Opts = {{ "Input",  {"Database",      "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},
            {"Network",      "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},
            {"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\9_Commodity.mtx",
                                     "SE",
                                     "Row Index",
                                     "Column Index"}},
            {"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_outs_SE.DBF"}},
            {"Field",  {"FF Time",      "Time"}},
            {"Global", {"Load Method",    1},
            {"Critical Link Flows", { 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15,
                                     16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
                                     31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 }}}},
```

```

{"Output", {"Flow Table", "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_outs_Total.bin"},
{"Critical Matrix", {"Label",
"Critical Matrix"},
{"File Name",
"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_outs_SE.mtx"}}}}

```

if !RunMacro("TCB Run Procedure", 16, "Assignment", Opts) then goto quit

// STEP 17: Assignment [outs_TX]

```

Opts = {"Input", {"Database", "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},
{"Network", "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},
{"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\9_Commodity.mtx",
"TX",
"Row Index",
"Column Index"}},
{"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_outs_TX.DBF"}},
{"Field", {"FF Time", "Time"}},
{"Global", {"Load Method", 1},
{"Critical Link Flows", { 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,
16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 }}}},
{"Output", {"Flow Table", "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_outs_Total.bin"},
{"Critical Matrix", {"Label",
"Critical Matrix"},
{"File Name",
"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_outs_TX.mtx"}}}}

```

if !RunMacro("TCB Run Procedure", 17, "Assignment", Opts) then goto quit

// STEP 18: Assignment [outs_WD]

```

Opts = {"Input", {"Database", "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},
{"Network", "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},
{"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\9_Commodity.mtx",
"WD",
"Row Index",
"Column Index"}},
{"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_outs_WD.DBF"}},

```

```

{"Field", {{ "FF Time",      "Time" }}},
{"Global", {{ "Load Method",    1},
            {"Critical Link Flows", { 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15,
                                      16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
                                      31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 } } }},

{"Output", {{ "Flow Table",      "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_outs_Total.bin"},
            {"Critical Matrix",  {"Label",
                                  "Critical Matrix"},
            {"File Name",
            "C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_outs_WD.mtx" } } } }

```

```

if !RunMacro("TCB Run Procedure", 18, "Assignment", Opts) then goto quit

```

```

// STEP 19: Assignment (ins_Total)

```

```

Opts = {{ "Input",  {{ "Database",      "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},
                    {"Network",      "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},
                    {"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\Total_TruckTons.mtx",
                                             "TruckTons_All",
                                             "Row Index",
                                             "Column Index" } }},
        {"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_ins_Total.DBF" } } }},
{"Field", {{ "FF Time",      "Time" }}},
{"Global", {{ "Load Method",    1},
            {"Critical Link Flows", { 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15,
                                      16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
                                      31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 } } }},

{"Output", {{ "Flow Table",      "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_ins_Total.bin"},
            {"Critical Matrix",  {"Label",
                                  "Critical Matrix"},
            {"File Name",
            "C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_ins_Total.mtx" } } } }

```

```

if !RunMacro("TCB Run Procedure", 19, "Assignment", Opts) then goto quit

```

```

// STEP 20: Assignment (Outs_Total)

```

```

Opts = {"Input", {"Database", "C:\\TexasSAM\\GeoFiles\\network20040310.DBD"},
        {"Network", "C:\\TexasSAM\\Net.Files\\98_Auto_for_Frgt.net"},
        {"OD Matrix Currency", {"C:\\TexasSAM\\INPUT_DATA\\Total_TruckTons.mtx",
                                "TruckTons_All",
                                "Row Index",
                                "Column Index"}},
        {"Critical Link Table", {"C:\\TEXASSAM\\CLINK_SET\\HGAC_CLINK_outs_total.DBF"}}},
{"Field", {"FF Time", "Time"}},
{"Global", {"Load Method", 1},
           {"Critical Link Flows", { 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,
                                    16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
                                    31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41 }}}},
{"Output", {"Flow Table", "C:\\TexasSAM\\OUTPUT_CLA\\ASN_LinkFlow_outs_Total.bin"},
           {"Critical Matrix", {"Label",
                                "Critical Matrix",
                                "File Name",
                                "C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_outs_Total.mtx"}}}}

```

if !RunMacro("TCB Run Procedure", 20, "Assignment", Opts) then goto quit

done:

Return(RunMacro("TCB Closing", 1, "TRUE"))

quit:

Return(RunMacro("TCB Closing", 0, "TRUE"))

endMacro

**INPUTS=18 INPUT FILES BY COMMODITY (PLUS 2 INPUT FILES FOR TOTAL)
 PURPOSE=RUN CLA EFFICIENTLY
 OUTPUTS= 738 CRITICAL MATRICES FOR 9 COMMODITY GROUPS (369 FOR
 INS CRITICAL TABLE AND 369 FOR OUTS CRITICAL TABLE). THESE WILL
 NEED FURTHER PROCESSING TO COMBINE INS AND OUTS TO ISOLATE
 BI-DIRECTIONAL FLOWS (AB FLOWS, BA FLOWS). IN ADDITIONS, 82
 CRITICAL MATRICES FOR TOTAL (41 FOR INS CRITICAL TABLE AND 41
 OUTS CRITICAL TABLE)
 TIME TAKEN FOR ROUTINE= 00:32:35 (hh:mm:ss)**

C2. For Adding Ins- and Outs-Critical Matrices

GISDK Document Filename: Mat_summation_Ins&Outs_01_AG

(“AG” = Commodity Group=Agriculture. For other commodity, choose the batch macro file with the abbreviation; raw material – “RM”, Food – “FD”, wood – “WD”, textile – “TX”, secondary – “SE”, building materials – “BM”, machinery – “MA” and chemical_petro – “CP”)

Macro "Batch Macro"

RunMacro("TCB Init")

// STEP 1: IH10E-hereafter AG

```
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "IH10E[AG]",
    "Rows",
    "Cols"}},
    {"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "IH10E[AG]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
    "IH10E[AG]",
    "Rows",
    "Cols"}}}},
    {"Global", {"Method", 7},
    {"Cell Range", 2},
    {"Matrix K", {1,
    1}},
    {"Force Missing", "No"}}}
```

if !RunMacro("TCB Run Operation", 1, "Fill Matrices", Opts) then goto quit

// STEP 2: IH10W

```
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "IH10W[AG]",
    "Rows",
    "Cols"}},
    {"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "IH10W[AG]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
    "IH10W[AG]",
    "Rows",
    "Cols"}}}},
    {"Global", {"Method", 7},
    {"Cell Range", 2},
    {"Matrix K", {1,
    1}},
    {"Force Missing", "No"}}}
```

if !RunMacro("TCB Run Operation", 2, "Fill Matrices", Opts) then goto quit

// STEP 3: IH45N

```
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "IH45N[AG]",
    "Rows",
    "Cols"}},
    {"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "IH45N[AG]",
```

```

        "Rows",
        "Cols"},
        {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
        "IH45N[AG]",
        "Rows",
        "Cols"}}}},
{"Global", {"Method", 7},
{"Cell Range", 2},
{"Matrix K", {1,
1}},
{"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 3, "Fill Matrices", Opts) then goto quit

// STEP 4: US90W
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"UA90W[AG]",
"Rows",
"Cols"}},
{"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"UA90W[AG]",
"Rows",
"Cols"}},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
"UA90W[AG]",
"Rows",
"Cols"}}}},
{"Global", {"Method", 7},
{"Cell Range", 2},
{"Matrix K", {1,
1}},
{"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 4, "Fill Matrices", Opts) then goto quit

// STEP 5: US290
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"US290[AG]",
"Rows",
"Cols"}},
{"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"US290[AG]",
"Rows",
"Cols"}},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
"US290[AG]",
"Rows",
"Cols"}}}},
{"Global", {"Method", 7},
{"Cell Range", 2},
{"Matrix K", {1,
1}},
{"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 5, "Fill Matrices", Opts) then goto quit

// STEP 6: US59NE
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"US59NE[AG]",

```



```

        "Rows",
        "Cols"}},
    {"Core Currencies", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
        "US59NE[AG]",
        "Rows",
        "Cols"},
        {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_OUTS_AG.MTX",
        "US59NE[AG]",
        "Rows",
        "Cols"}}}},
    {"Global", {"Method", 7},
        {"Cell Range", 2},
        {"Matrix K", {1,
            1}},
        {"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 6, "Fill Matrices", Opts) then goto quit

// STEP 7: US59W
    Opts = {"Input", {"Matrix Currency", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
        "US59W[AG]",
        "Rows",
        "Cols"}},
        {"Core Currencies", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
        "US59W[AG]",
        "Rows",
        "Cols"},
        {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_OUTS_AG.MTX",
        "US59W[AG]",
        "Rows",
        "Cols"}}}},
    {"Global", {"Method", 7},
        {"Cell Range", 2},
        {"Matrix K", {1,
            1}},
        {"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 7, "Fill Matrices", Opts) then goto quit

// STEP 8: US90E
    Opts = {"Input", {"Matrix Currency", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
        "US90E[AG]",
        "Rows",
        "Cols"}},
        {"Core Currencies", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
        "US90E[AG]",
        "Rows",
        "Cols"},
        {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_OUTS_AG.MTX",
        "US90E[AG]",
        "Rows",
        "Cols"}}}},
    {"Global", {"Method", 7},
        {"Cell Range", 2},
        {"Matrix K", {1,
            1}},
        {"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 8, "Fill Matrices", Opts) then goto quit

```

```
// STEP 9: SH105E
  Opts = {"Input", {"Matrix Currency", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
    "SH105E[AG]",
    "Rows",
    "Cols"}},
    {"Core Currencies", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
    "SH105E[AG]",
    "Rows",
    "Cols"},
    {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_OUTS_AG.MTX",
    "SH105E[AG]",
    "Rows",
    "Cols"}}}},
  {"Global", {"Method", 7},
  {"Cell Range", 2},
  {"Matrix K", {1,
    1}},
  {"Force Missing", "No"}}}

if !RunMacro("TCB Run Operation", 9, "Fill Matrices", Opts) then goto quit
```

```
// STEP 10: SH105W
  Opts = {"Input", {"Matrix Currency", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
    "SH105W[AG]",
    "Rows",
    "Cols"}},
    {"Core Currencies", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
    "SH105W[AG]",
    "Rows",
    "Cols"},
    {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_OUTS_AG.MTX",
    "SH105W[AG]",
    "Rows",
    "Cols"}}}},
  {"Global", {"Method", 7},
  {"Cell Range", 2},
  {"Matrix K", {1,
    1}},
  {"Force Missing", "No"}}}

if !RunMacro("TCB Run Operation", 10, "Fill Matrices", Opts) then goto quit
```

```
// STEP 11: SH146
  Opts = {"Input", {"Matrix Currency", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
    "SH146[AG]",
    "Rows",
    "Cols"}},
    {"Core Currencies", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
    "SH146[AG]",
    "Rows",
    "Cols"},
    {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_OUTS_AG.MTX",
    "SH146[AG]",
    "Rows",
    "Cols"}}}},
  {"Global", {"Method", 7},
  {"Cell Range", 2},
  {"Matrix K", {1,
    1}},
  {"Force Missing", "No"}}}
```

```
if !RunMacro("TCB Run Operation", 11, "Fill Matrices", Opts) then goto quit
```

```
// STEP 12: [SH159]
```

```
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",  
"SH159[AG]",  
"Rows",  
"Cols"}},  
{"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",  
"SH159[AG]",  
"Rows",  
"Cols"},  
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",  
"SH159[AG]",  
"Rows",  
"Cols"}}}},  
{"Global", {"Method", 7},  
{"Cell Range", 2},  
{"Matrix K", {1,  
1}},  
{"Force Missing", "No"}}}
```

```
if !RunMacro("TCB Run Operation", 12, "Fill Matrices", Opts) then goto quit
```

```
// STEP 13: [SH35]
```

```
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",  
"SH35[AG]",  
"Rows",  
"Cols"}},  
{"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",  
"SH35[AG]",  
"Rows",  
"Cols"},  
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",  
"SH35[AG]",  
"Rows",  
"Cols"}}}},  
{"Global", {"Method", 7},  
{"Cell Range", 2},  
{"Matrix K", {1,  
1}},  
{"Force Missing", "No"}}}
```

```
if !RunMacro("TCB Run Operation", 13, "Fill Matrices", Opts) then goto quit
```

```
// STEP 14: [SH36]
```

```
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",  
"SH36[AG]",  
"Rows",  
"Cols"}},  
{"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",  
"SH36[AG]",  
"Rows",  
"Cols"},  
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",  
"SH36[AG]",  
"Rows",  
"Cols"}}}},  
{"Global", {"Method", 7},
```

```

{"Cell Range", 2},
{"Matrix K", {1,
1}},
{"Force Missing", "No"}}}

```

if !RunMacro("TCB Run Operation", 14, "Fill Matrices", Opts) then goto quit

// STEP 15: [SH6]

```

Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"SH6[AG]",
"Rows",
"Cols"}},
{"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"SH6[AG]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
"SH6[AG]",
"Rows",
"Cols"}}}},
{"Global", {"Method", 7},
{"Cell Range", 2},
{"Matrix K", {1,
1}},
{"Force Missing", "No"}}}

```

if !RunMacro("TCB Run Operation", 15, "Fill Matrices", Opts) then goto quit

// STEP 16: [SH75]

```

Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"SH75[AG]",
"Rows",
"Cols"}},
{"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"SH75[AG]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
"SH75[AG]",
"Rows",
"Cols"}}}},
{"Global", {"Method", 7},
{"Cell Range", 2},
{"Matrix K", {1,
1}},
{"Force Missing", "No"}}}

```

if !RunMacro("TCB Run Operation", 16, "Fill Matrices", Opts) then goto quit

// STEP 17: [SH73]

```

Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"SH73[AG]",
"Rows",
"Cols"}},
{"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"SH73[AG]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",

```

```

                "SH73[AG]",
                "Rows",
                "Cols"}}}},
{"Global", {"Method", 7},
           {"Cell Range", 2},
           {"Matrix K", {1,
                        1}},
           {"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 17, "Fill Matrices", Opts) then goto quit

// STEP 18: [SH87E]
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
                                     "SH87E[AG]",
                                     "Rows",
                                     "Cols"}},
        {"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
                              "SH87E[AG]",
                              "Rows",
                              "Cols"},
         {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
          "SH87E[AG]",
          "Rows",
          "Cols"}}}},
{"Global", {"Method", 7},
           {"Cell Range", 2},
           {"Matrix K", {1,
                        1}},
           {"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 18, "Fill Matrices", Opts) then goto quit

// STEP 19: [FM149]
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
                                     "FM149[AG]",
                                     "Rows",
                                     "Cols"}},
        {"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
                              "FM149[AG]",
                              "Rows",
                              "Cols"},
         {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
          "FM149[AG]",
          "Rows",
          "Cols"}}}},
{"Global", {"Method", 7},
           {"Cell Range", 2},
           {"Matrix K", {1,
                        1}},
           {"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 19, "Fill Matrices", Opts) then goto quit

// STEP 20: [FM223]
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
                                     "FM223[AG]",
                                     "Rows",
                                     "Cols"}},
        {"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",

```

```

        "FM223[AG]",
        "Rows",
        "Cols"},
        {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
        "FM223[AG]",
        "Rows",
        "Cols"}}}},
    {"Global", {"Method", 7},
    {"Cell Range", 2},
    {"Matrix K", 1},
    {"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 20, "Fill Matrices", Opts) then goto quit

// STEP 21: [FM362]
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "FM362[AG]",
    "Rows",
    "Cols"}},
    {"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "FM362[AG]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
    "FM362[AG]",
    "Rows",
    "Cols"}}}},
    {"Global", {"Method", 7},
    {"Cell Range", 2},
    {"Matrix K", 1},
    {"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 21, "Fill Matrices", Opts) then goto quit

// STEP 22: [FM442]
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "FM442[AG]",
    "Rows",
    "Cols"}},
    {"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "FM442[AG]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
    "FM442[AG]",
    "Rows",
    "Cols"}}}},
    {"Global", {"Method", 7},
    {"Cell Range", 2},
    {"Matrix K", 1},
    {"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 22, "Fill Matrices", Opts) then goto quit

// STEP 23: [FM521]
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",

```

```

        "FM521[AG]",
        "Rows",
        "Cols"}},
{"Core Currencies", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
        "FM521[AG]",
        "Rows",
        "Cols"},
        {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_OUTS_AG.MTX",
        "FM521[AG]",
        "Rows",
        "Cols"}}}},
{"Global", {"Method", 7},
        {"Cell Range", 2},
        {"Matrix K", {1,
        1}},
        {"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 23, "Fill Matrices", Opts) then goto quit

// STEP 24: [FM529]
Opts = {"Input", {"Matrix Currency", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
        "FM529[AG]",
        "Rows",
        "Cols"}},
{"Core Currencies", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
        "FM529[AG]",
        "Rows",
        "Cols"},
        {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_OUTS_AG.MTX",
        "FM529[AG]",
        "Rows",
        "Cols"}}}},
{"Global", {"Method", 7},
        {"Cell Range", 2},
        {"Matrix K", {1,
        1}},
        {"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 24, "Fill Matrices", Opts) then goto quit

// STEP 25: FM770
Opts = {"Input", {"Matrix Currency", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
        "FM770[AG]",
        "Rows",
        "Cols"}},
{"Core Currencies", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
        "FM770[AG]",
        "Rows",
        "Cols"},
        {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_OUTS_AG.MTX",
        "FM770[AG]",
        "Rows",
        "Cols"}}}},
{"Global", {"Method", 7},
        {"Cell Range", 2},
        {"Matrix K", {1,
        1}},
        {"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 25, "Fill Matrices", Opts) then goto quit

```

```
// STEP 26: [FM787]
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "FM787[AG]",
    "Rows",
    "Cols"}},
    {"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "FM787[AG]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
    "FM787[AG]",
    "Rows",
    "Cols"}}}},
    {"Global", {"Method", 7},
    {"Cell Range", 2},
    {"Matrix K", {1,
    1}},
    {"Force Missing", "No"}}}
```

if !RunMacro("TCB Run Operation", 26, "Fill Matrices", Opts) then goto quit

```
// STEP 27: [FM1093]
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "FM1093[AG]",
    "Rows",
    "Cols"}},
    {"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "FM1093[AG]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
    "FM1093[AG]",
    "Rows",
    "Cols"}}}},
    {"Global", {"Method", 7},
    {"Cell Range", 2},
    {"Matrix K", {1,
    1}},
    {"Force Missing", "No"}}}
```

if !RunMacro("TCB Run Operation", 27, "Fill Matrices", Opts) then goto quit

```
// STEP 28: [FM1097]
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "FM1097[AG]",
    "Rows",
    "Cols"}},
    {"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "FM1097[AG]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
    "FM1097[AG]",
    "Rows",
    "Cols"}}}},
    {"Global", {"Method", 7},
    {"Cell Range", 2},
    {"Matrix K", {1,
```



```

        1}},
        {"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 28, "Fill Matrices", Opts) then goto quit

// STEP 29: [FM1301]
Opts = {"Input", {"Matrix Currency", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
    "FM1301[AG]",
    "Rows",
    "Cols"}},
    {"Core Currencies", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
    "FM1301[AG]",
    "Rows",
    "Cols"},
    {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_OUTS_AG.MTX",
    "FM1301[AG]",
    "Rows",
    "Cols"}}}},
    {"Global", {"Method", 7},
    {"Cell Range", 2},
    {"Matrix K", {1,
    1}},
    {"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 29, "Fill Matrices", Opts) then goto quit

// STEP 30: [FM1375]
Opts = {"Input", {"Matrix Currency", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
    "FM1375[AG]",
    "Rows",
    "Cols"}},
    {"Core Currencies", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
    "FM1375[AG]",
    "Rows",
    "Cols"},
    {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_OUTS_AG.MTX",
    "FM1375[AG]",
    "Rows",
    "Cols"}}}},
    {"Global", {"Method", 7},
    {"Cell Range", 2},
    {"Matrix K", {1,
    1}},
    {"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 30, "Fill Matrices", Opts) then goto quit

// STEP 31: [FM1406N]
Opts = {"Input", {"Matrix Currency", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
    "FM1406N[AG]",
    "Rows",
    "Cols"}},
    {"Core Currencies", {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_INS_AG.MTX",
    "FM1406N[AG]",
    "Rows",
    "Cols"},
    {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_OUTS_AG.MTX",
    "FM1406N[AG]",
    "Rows",
    "Rows",
    "Cols"},
    {"C:\TexasSAM\OUTPUT_CLA\ASN_CRITICAL_OUTS_AG.MTX",
    "FM1406N[AG]",
    "Rows",
    "Rows",
    "Cols"}},
    {"Global", {"Method", 7},
    {"Cell Range", 2},
    {"Matrix K", {1,
    1}},
    {"Force Missing", "No"}}}}

```

```

        "Cols"}}}}},
{"Global", {"Method", 7},
{"Cell Range", 2},
{"Matrix K", {1,
1}},
{"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 31, "Fill Matrices", Opts) then goto quit

// STEP 32: [FM1406S]
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"FM1406S[AG]",
"Rows",
"Cols"}},
{"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"FM1406S[AG]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
"FM1406S[AG]",
"Rows",
"Cols"}}}},
{"Global", {"Method", 7},
{"Cell Range", 2},
{"Matrix K", {1,
1}},
{"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 32, "Fill Matrices", Opts) then goto quit

// STEP 33: [FM1486]
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"FM1486[AG]",
"Rows",
"Cols"}},
{"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"FM1486[AG]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
"FM1486[AG]",
"Rows",
"Cols"}}}},
{"Global", {"Method", 7},
{"Cell Range", 2},
{"Matrix K", {1,
1}},
{"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 33, "Fill Matrices", Opts) then goto quit

// STEP 34: [FM1725]
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"FM1725[AG]",
"Rows",
"Cols"}},
{"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"FM1725[AG]",
"Rows",

```

```

        "Cols"},
        {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
        "FM1725[AG]",
        "Rows",
        "Cols"}}}},
{"Global", {"Method", 7},
{"Cell Range", 2},
{"Matrix K", {1,
1}},
{"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 34, "Fill Matrices", Opts) then goto quit

// STEP 35: [FM1774]
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"FM1774[AG]",
"Rows",
"Cols"}},
{"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"FM1774[AG]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
"FM1774[AG]",
"Rows",
"Cols"}}}},
{"Global", {"Method", 7},
{"Cell Range", 2},
{"Matrix K", {1,
1}},
{"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 35, "Fill Matrices", Opts) then goto quit

// STEP 36: [FM1791]
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"FM1791[AG]",
"Rows",
"Cols"}},
{"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"FM1791[AG]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
"FM1791[AG]",
"Rows",
"Cols"}}}},
{"Global", {"Method", 7},
{"Cell Range", 2},
{"Matrix K", {1,
1}},
{"Force Missing", "No"}}}}

if !RunMacro("TCB Run Operation", 36, "Fill Matrices", Opts) then goto quit

// STEP 37: [FM2025]
Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
"FM2025[AG]",
"Rows",

```

```

        "Cols"}},
    {"Core Currencies", {{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
        "FM2025[AG]",
        "Rows",
        "Cols"},
        {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
        "FM2025[AG]",
        "Rows",
        "Cols"}}}},
    {"Global", {{"Method", 7},
        {"Cell Range", 2},
        {"Matrix K", {1,
            1}},
        {"Force Missing", "No"}}}}

```

if !RunMacro("TCB Run Operation", 37, "Fill Matrices", Opts) then goto quit

// STEP 38: [FM2611]

```

    Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
        "FM2611[AG]",
        "Rows",
        "Cols"}},
        {"Core Currencies", {{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
        "FM2611[AG]",
        "Rows",
        "Cols"},
        {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
        "FM2611[AG]",
        "Rows",
        "Cols"}}}},
        {"Global", {{"Method", 7},
        {"Cell Range", 2},
        {"Matrix K", {1,
            1}},
        {"Force Missing", "No"}}}}

```

if !RunMacro("TCB Run Operation", 38, "Fill Matrices", Opts) then goto quit

// STEP 39: [CP]

```

    Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
        "CP[AG]",
        "Rows",
        "Cols"}},
        {"Core Currencies", {{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
        "CP[AG]",
        "Rows",
        "Cols"},
        {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
        "CP[AG]",
        "Rows",
        "Cols"}}}},
        {"Global", {{"Method", 7},
        {"Cell Range", 2},
        {"Matrix K", {1,
            1}},
        {"Force Missing", "No"}}}}

```

if !RunMacro("TCB Run Operation", 39, "Fill Matrices", Opts) then goto quit

```

// STEP 40: [HP]
  Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "HP[AG]",
    "Rows",
    "Cols"}},
    {"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "HP[AG]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
    "HP[AG]",
    "Rows",
    "Cols"}}}},
  {"Global", {"Method", 7},
    {"Cell Range", 2},
    {"Matrix K", {1,
    1}},
    {"Force Missing", "No"}}}

  if !RunMacro("TCB Run Operation", 40, "Fill Matrices", Opts) then goto quit

// STEP 41: [GP]
  Opts = {"Input", {"Matrix Currency", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "GP[AG]",
    "Rows",
    "Cols"}},
    {"Core Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_AG.MTX",
    "GP[AG]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_OUTS_AG.MTX",
    "GP[AG]",
    "Rows",
    "Cols"}}}},
  {"Global", {"Method", 7},
    {"Cell Range", 2},
    {"Matrix K", {1,
    1}},
    {"Force Missing", "No"}}}

  if !RunMacro("TCB Run Operation", 41, "Fill Matrices", Opts) then goto quit

done:
Return( RunMacro("TCB Closing", 1, "TRUE" ) )
quit:
Return( RunMacro("TCB Closing", 0, "TRUE" ) )
EndMacro

```

INPUTS=2 INS- & OUTS-CIRITICAL MATRICES BY COMMODITY GROUP
PURPOSE=ADDING INS- & OUTS-CRITICAL MATRICES EFFICIENTLY
OUTPUTS= CRITICAL MATRICES BY 9 COMMODITY GROUPS. THESE WILL
NEED FURTHER PROCESSING TO COMBINE 9 CRITICAL MATRICES
FILES INTO A FILE.
TIME TAKEN FOR ROUTINE (AG)= 00:00:25 (hh:mm:ss)
TIMES TAKEN FOR 9 COMMODITIES AND TOTAL = 00:03:55 (hh:mm:ss)

C3. For Combining Nine Critical Matrices Files

GISDK Document Filename: Mat Final Combine Critical Matrix for HGAC

```
Macro "Batch Macro"
  RunMacro("TCB Init")
// STEP 1: Combine Matrix Files
  Opts = {"Input", {"Matrix Currencies", {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
    "IH10E[TX]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
    "IH10W[TX]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
    "IH45N[TX]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
    "UA90W[TX]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
    "US290[TX]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
    "US59NE[TX]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
    "US59W[TX]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
    "US90E[TX]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
    "SH105E[TX]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
    "SH105W[TX]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
    "SH146[TX]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
    "SH159[TX]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
    "SH35[TX]",
    "Rows",
    "Cols"},
    {"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
    "SH36[TX]"
```

"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"SH6[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"SH73[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"SH75[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"SH87E[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM149[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM223[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM362[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM442[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM521[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM529[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM770[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM787[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM1093[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM1097[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM1301[TX]",
"Rows",
"Cols"},

```

"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM1375[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM1406N[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM1406S[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM1486[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM1725[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM1774[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM1791[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM2025[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"FM2611[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"CP[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"HP[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_TX.MTX",
"GP[TX]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"IH10E[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"IH10W[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"IH45N[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"UA90W[SE]",

```



```

"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"US290[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"US59NE[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"US59W[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"US90E[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"SH105E[SE]",
"Rows",
"Cols"} + {
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"SH105W[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"SH146[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"SH159[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"SH35[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"SH36[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"SH6[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"SH73[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"SH75[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"SH87E[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"FM149[SE]",
"Rows",
"Cols"},

```

```

"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"FM223[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"FM362[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"FM442[SE]",
"Rows",
"Cols"},
{"C:\\TexasSAM\\OUTPUT_CLA\\ASN_CRITICAL_INS_SE.MTX",
"FM521[SE]",
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quit:
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endMacro
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INPUTS=9 CRITICAL MATRICES FILES

PURPOSE=COMBING 9 CRITICAL MATRICES FILES INTO ONE FILE EFFICIENTLY

**OUTPUTS= A FILE WITH 369 MATRIIES BY 41 CRITICAL LINKS AND 9
COMMODITY GROUPS**

TIME TAKEN FOR ROUTINE (AG)= 00:02:55 (hh:mm:ss)

**APPENDIX F:
DEFAULT RATES FOR MODELING COMMODITY,
NON-TRANSFER VEHICLE, AND EMPTY VEHICLE MOVEMENTS**

Table F-1. Default Commodity Shipping Rates.

Residential – Quarter Tons Per Household					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0000	0.0000	0.0000	0.0000	0.0000
Raw Materials	0.0148	0.0148	0.0148	0.0148	0.0148
Food	0.0000	0.0000	0.0000	0.0000	0.0000
Textiles	0.0007	0.0007	0.0007	0.0007	0.0007
Wood	0.0036	0.0036	0.0036	0.0036	0.0036
Building Materials	0.0162	0.0162	0.0162	0.0162	0.0162
Machinery	0.0151	0.0151	0.0151	0.0151	0.0151
Miscellaneous	0.0289	0.0289	0.0289	0.0289	0.0289
Secondary	0.0000	0.0000	0.0000	0.0000	0.0000
Hazardous	0.0000	0.0000	0.0000	0.0000	0.0000
Basic Employment - Quarter Tons Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0324	0.0357	0.0521	0.0340	0.0335
Raw Materials	0.3472	0.4504	0.7181	0.5109	0.3257
Food	0.1599	0.2083	0.3279	0.2402	0.1427
Textiles	0.0081	0.0136	0.0291	0.0155	0.0131
Wood	0.3413	0.0752	0.1940	0.0663	0.1174
Building Materials	0.2063	0.3691	0.9034	0.3753	0.4768
Machinery	0.1016	0.1635	0.4034	0.1444	0.2458
Miscellaneous	0.4826	0.5071	0.7081	0.4614	0.4934
Secondary	0.0276	0.0316	0.0389	0.0369	0.0162
Hazardous	0.0868	0.0893	0.1162	0.0825	0.0812
Retail Employment – Quarter Tons Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0036	0.0026	0.0027	0.0043	0.0030
Raw Materials	0.0126	0.0172	0.0124	0.1578	0.1562
Food	0.0887	0.0990	0.0876	0.2217	0.1943
Textiles	0.0780	0.0325	0.0329	0.0052	0.0121
Wood	0.0391	0.0221	0.0327	0.0126	0.0087
Building Materials	0.0422	0.0434	0.0382	0.3880	0.3824
Machinery	0.0722	0.0513	0.0672	0.1339	0.0861
Miscellaneous	0.0353	0.0383	0.0373	0.0474	0.0360
Secondary	0.0083	0.0114	0.0090	0.0068	0.0068
Hazardous	0.0257	0.0329	0.0317	0.0241	0.0235
Service Employment – Quarter Tons Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0057	0.0118	0.0081	0.0060	0.0556
Raw Materials	0.0505	0.1194	0.1186	0.1325	0.2073
Food	0.0210	0.0387	0.0572	0.0618	0.0525
Textiles	0.0029	0.0061	0.0039	0.0022	0.0334
Wood	0.0082	0.0211	0.0166	0.0155	0.0824
Building Materials	0.0949	0.1394	0.1141	0.0942	0.5152
Machinery	0.0399	0.0933	0.0616	0.0469	0.4014
Miscellaneous	0.0586	0.1817	0.1662	0.1868	0.4546
Secondary	0.0018	0.0097	0.0060	0.0073	0.0068
Hazardous	0.0008	0.0027	0.0027	0.0034	0.0034

Table F-2. Default Commodity Receiving Rates.

Residential – Quarter Tons Per Household					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0028	0.0028	0.0028	0.0028	0.0028
Raw Materials	0.0104	0.0104	0.0104	0.0104	0.0104
Food	0.0070	0.0070	0.0070	0.0070	0.0070
Textiles	0.0061	0.0061	0.0061	0.0061	0.0061
Wood	0.0550	0.0550	0.0550	0.0550	0.0550
Building Materials	0.2687	0.2687	0.2687	0.2687	0.2687
Machinery	0.0153	0.0153	0.0153	0.0153	0.0153
Miscellaneous	0.0142	0.0142	0.0142	0.0142	0.0142
Secondary	0.0057	0.0057	0.0057	0.0057	0.0057
Hazardous	0.0015	0.0015	0.0015	0.0015	0.0015
Basic Employment – Quarter Tons Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0449	0.0467	0.0628	0.0426	0.0442
Raw Materials	0.2810	0.3405	0.5414	0.3503	0.3000
Food	0.0590	0.0952	0.1518	0.1361	0.0262
Textiles	0.0083	0.0110	0.0168	0.0467	0.0062
Wood	0.0207	0.0305	0.0649	0.0298	0.0368
Building Materials	0.7497	0.9733	1.4024	1.1982	0.4924
Machinery	0.1103	0.1444	0.2771	0.1362	0.1676
Miscellaneous	0.4880	0.5050	0.6615	0.4685	0.4578
Secondary	0.0026	0.0047	0.0075	0.0075	0.0002
Hazardous	0.0883	0.0893	0.1100	0.0832	0.0772
Retail Employment – Quarter Tons Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0059	0.0050	0.0043	0.0030	0.0197
Raw Materials	0.1699	0.2413	0.1578	0.1562	0.3907
Food	0.2176	0.2160	0.2217	0.1943	0.5068
Textiles	0.0224	0.0690	0.0052	0.0121	0.0730
Wood	0.0142	0.0423	0.0126	0.0087	0.0433
Building Materials	0.3387	0.4381	0.3880	0.3824	0.5786
Machinery	0.1573	0.0765	0.1339	0.0861	0.5076
Miscellaneous	0.0497	0.0339	0.0474	0.0360	0.1373
Secondary	0.0059	0.0080	0.0068	0.0068	0.0098
Hazardous	0.0203	0.0251	0.0241	0.0235	0.0332
Service Employment – Quarter Tons Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0026	0.0086	0.0063	0.0071	0.0149
Raw Materials	0.0797	0.1189	0.1984	0.2006	0.2567
Food	0.0768	0.0493	0.0737	0.0747	0.1071
Textiles	0.0037	0.0055	0.0054	0.0039	0.0294
Wood	0.0271	0.0522	0.0479	0.0405	0.2386
Building Materials	0.1898	0.3415	0.3868	0.3686	1.1351
Machinery	0.0490	0.0902	0.0668	0.0447	0.4610
Miscellaneous	0.0550	0.1562	0.2012	0.2157	0.4574
Secondary	0.0010	0.0053	0.0032	0.0039	0.0036
Hazardous	0.0032	0.0064	0.0053	0.0042	0.0345

Table F-3. Default Commodity Non-Transfer Production Rates.

Residential –Vehicle Trips Per Household					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0003	0.0003	0.0003	0.0003	0.0003
Raw Materials	0.0051	0.0051	0.0051	0.0051	0.0051
Food	0.0005	0.0005	0.0005	0.0005	0.0005
Textiles	0.0006	0.0006	0.0006	0.0006	0.0006
Wood	0.0079	0.0079	0.0079	0.0079	0.0079
Building Materials	0.0026	0.0026	0.0026	0.0026	0.0026
Machinery	0.0055	0.0055	0.0055	0.0055	0.0055
Miscellaneous	0.0096	0.0096	0.0096	0.0096	0.0096
Secondary	0.0044	0.0044	0.0044	0.0044	0.0044
Hazardous	0.0005	0.0005	0.0005	0.0005	0.0005
Basic Employment –Vehicle Trips Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0069	0.0065	0.0066	0.0059	0.0052
Raw Materials	0.0203	0.0232	0.0345	0.0232	0.0204
Food	0.0081	0.0098	0.0177	0.0086	0.0119
Textiles	0.0042	0.0056	0.0090	0.0065	0.0039
Wood	0.0093	0.0105	0.1048	0.0092	0.0120
Building Materials	0.0161	0.0189	0.0295	0.0189	0.0173
Machinery	0.0346	0.0693	0.0715	0.0360	0.0481
Miscellaneous	0.0370	0.0412	0.0666	0.0359	0.0467
Secondary	0.0029	0.0030	0.0035	0.0033	0.0019
Hazardous	0.0136	0.0135	0.0160	0.0125	0.0116
Retail Employment – Vehicle Trips Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0019	0.0013	0.0014	0.0009	0.0064
Raw Materials	0.0164	0.0188	0.0187	0.0177	0.0302
Food	0.1026	0.0844	0.0997	0.0808	0.2671
Textiles	0.0080	0.0067	0.0074	0.0059	0.0218
Wood	0.0114	0.0083	0.0113	0.0090	0.0292
Building Materials	0.0051	0.0051	0.0055	0.0048	0.0113
Machinery	0.0469	0.0347	0.0466	0.0369	0.1219
Miscellaneous	0.0432	0.0380	0.0464	0.0398	0.0967
Secondary	0.0031	0.0040	0.0038	0.0038	0.0044
Hazardous	0.0016	0.0008	0.0013	0.0008	0.0053
Service Employment – Vehicle Trips Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0057	0.0015	0.0009	0.0008	0.0050
Raw Materials	0.0050	0.0103	0.0097	0.0087	0.0441
Food	0.0102	0.0190	0.0208	0.0193	0.0763
Textiles	0.0021	0.0041	0.0039	0.0039	0.0118
Wood	0.0043	0.0104	0.0087	0.0083	0.0365
Building Materials	0.0094	0.0172	0.0194	0.0183	0.0611
Machinery	0.0187	0.0344	0.0273	0.0201	0.1794
Miscellaneous	0.0134	0.0426	0.0405	0.0470	0.1028
Secondary	0.0001	0.0026	0.0023	0.0030	0.0030
Hazardous	0.0007	0.0017	0.0019	0.0019	0.0053

Table F-4. Default Commodity Non-Transfer Attraction Rates.

Residential – Vehicle Trips Per Household					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0000	0.0000	0.0000	0.0000	0.0000
Raw Materials	0.0006	0.0006	0.0006	0.0006	0.0006
Food	0.0000	0.0000	0.0000	0.0000	0.0000
Textiles	0.0003	0.0003	0.0003	0.0003	0.0003
Wood	0.0053	0.0053	0.0053	0.0053	0.0053
Building Materials	0.0047	0.0047	0.0047	0.0047	0.0047
Machinery	0.0066	0.0066	0.0066	0.0066	0.0066
Miscellaneous	0.0083	0.0083	0.0083	0.0083	0.0083
Secondary	0.0005	0.0005	0.0005	0.0005	0.0005
Hazardous	0.0000	0.0000	0.0000	0.0000	0.0000
Basic Employment – Vehicle Trips Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0078	0.0072	0.0073	0.0066	0.0058
Raw Materials	0.0240	0.0257	0.0334	0.0257	0.0204
Food	0.0061	0.0064	0.0083	0.0062	0.0054
Textiles	0.0014	0.0025	0.0052	0.0030	0.0020
Wood	0.0023	0.0035	0.0077	0.0032	0.0046
Building Materials	0.0110	0.0145	0.0267	0.0144	0.0153
Machinery	0.0206	0.0257	0.0483	0.0231	0.0310
Miscellaneous	0.0255	0.0286	0.0458	0.0255	0.0313
Secondary	0.0063	0.0065	0.0073	0.0068	0.0042
Hazardous	0.0051	0.0053	0.0071	0.0050	0.0048
Retail Employment – Vehicle Trips Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0000	0.0000	0.0000	0.0000	0.0000
Raw Materials	0.0031	0.0029	0.0032	0.0028	0.0069
Food	0.0036	0.0039	0.0037	0.0033	0.0084
Textiles	0.0025	0.0021	0.0022	0.0017	0.0073
Wood	0.0052	0.0050	0.0056	0.0049	0.0116
Building Materials	0.0019	0.0018	0.0020	0.0018	0.0043
Machinery	0.0151	0.0141	0.0161	0.0141	0.0333
Miscellaneous	0.0132	0.0111	0.0136	0.0114	0.0318
Secondary	0.0031	0.0040	0.0039	0.0039	0.0043
Hazardous	0.0026	0.0033	0.0032	0.0032	0.0035
Service Employment – Vehicle Trips Per Employee					
Commodity	Area Type				
	1	2	3	4	5
Agriculture	0.0006	0.0022	0.0018	0.0020	0.0056
Raw Materials	0.0019	0.0049	0.0041	0.0041	0.0155
Food	0.0014	0.0030	0.0032	0.0033	0.0088
Textiles	0.0022	0.0043	0.0026	0.0012	0.0257
Wood	0.0025	0.0053	0.0048	0.0043	0.0217
Building Materials	0.0030	0.0066	0.0049	0.0041	0.0282
Machinery	0.0062	0.0155	0.0127	0.0122	0.0532
Miscellaneous	0.0105	0.0349	0.0323	0.0376	0.0833
Secondary	0.0002	0.0009	0.0007	0.0009	0.0009
Hazardous	0.0002	0.0009	0.0008	0.0010	0.0011

Table F-5. Default Empty Vehicle Production and Attraction Rates.

Empty Vehicle Trip Rates – Productions					
Land Use	Area Type				
	1	2	3	4	5
Residential	0.0262	0.0262	0.0262	0.0262	0.0262
Basic Employment	0.0970	0.1067	0.1433	0.1086	0.1195
Retail Employment	0.0719	0.0775	0.0818	0.0759	0.0784
Service Employment	0.0231	0.0728	0.0710	0.0826	0.0754
Empty Vehicle Trip Rates – Attractions					
Land Use	Area Type				
	1	2	3	4	5
Residential	0.0394	0.0394	0.0394	0.0394	0.0394
Basic Employment	0.1350	0.1478	0.1987	0.1490	0.1652
Retail Employment	0.0435	0.0503	0.0512	0.0489	0.0501
Service Employment	0.0248	0.0786	0.0765	0.0896	0.0815

Table F-6. Average Shipping Weights (Qtr Tons) for Internal Commodity Movements.

Commodity Group	Residential	Basic	Retail	Service
Agriculture	0.00	13.56	4.11	7.46
Raw Materials	21.42	30.71	11.51	28.16
Food	0.00	21.72	9.94	7.36
Textiles	2.01	3.43	6.55	2.20
Wood	10.21	9.61	7.23	5.38
Building Materials	14.35	27.51	23.33	19.92
Machinery	3.78	6.50	8.21	5.72
Miscellaneous	7.54	17.00	7.04	9.84
Secondary	0.00	5.26	5.17	6.48
Hazardous	0.00	18.00	12.99	6.41

Table F-7. Average Receiving Weights (Qtr Tons) for Internal Commodity Movements.

Commodity Group	Residential	Basic	Retail	Service
Agriculture	2.68	11.20	1.43	7.99
Raw Materials	6.06	14.58	19.55	16.02
Food	6.01	11.64	1.78	2.19
Textiles	2.97	1.05	1.79	1.63
Wood	5.83	5.04	4.78	3.28
Building Materials	19.99	22.88	15.82	19.53
Machinery	4.71	3.39	2.90	2.78
Miscellaneous	5.09	12.07	3.33	7.11
Secondary	5.10	3.09	2.13	3.70
Hazardous	3.62	7.39	12.56	4.37

