

# **Developer's Guide**

## **for the**

# **Multimodal Statewide Freight Transportation Model**

This guide describes the procedures to reconstruct the statewide multimodal freight transportation model and its inputs as developed for the Iowa DOT by the ISU Center for Transportation Research and Education. Specific steps to construct and evaluate the model are detailed in this Guide.

The following conditions describe the hardware and software by which the model had been constructed:

#### Hardware Requirements:

- PC with DOS and Windows 95 or Windows NT 3.51 (or any more recent Windows version of each).

#### Software requirements:

- TRANPLAN v. 8.0 or higher
- MapInfo 4.0 or higher
- MapBasic 4.0 or higher
- Text file editor (Notepad, Textpad, Write, etc.)

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## Table of Contents

<i>Model Objective</i> .....	2
<i>General Layout of Methodology</i> .....	3
<i>Commodity Flow Data</i> .....	4
<i>Zonal Structure</i> .....	7
<i>Highway Network Definition</i> .....	9
<i>Highway Network Attributes</i> .....	10
<i>Railroad Network Definition</i> .....	10
<i>Railroad Network Assumptions</i> .....	11
<i>Railroad Network Attributes</i> .....	12
<i>Intermodal Transfer Definition</i> .....	13
<i>Intermodal Transfer Attributes</i> .....	14
<i>Modeling Process</i> .....	14
<i>Trip Generation</i> .....	15
<i>Trip Distribution</i> .....	15
<i>Mode Split and Traffic Assignment (Combined)</i> .....	17
<i>Model Output</i> .....	17
<i>Calibration and Validation of Modeling Methodology</i> .....	18
<i>Policy Sensitivity</i> .....	19

### *Model Objective*

To ascertain the modal freight traffic volumes which result from changes in modal transportation costs. Freight transportation policy, infrastructure investment, or transport technology may cause such changes in transport cost.

### ***General Layout of Methodology***

As developed, this modeling process closely follows that of the conventional, four-step urban transportation modeling system (UTMS). The UTMS process involves: 1) trip generation to determine zonal productions and attractions, 2) trip distribution to predict zone to zone flows, 3) mode split to determine the type of transport, and 4) traffic assignment to theorize the path on which the trip will be made.

Trip generation, the first step in the UTMS procedure, does not occur in this modeling process in the traditional manner. Measures of trip production and attraction already exist in the available commodity flow data, as will be described later. Thus, theoretical trip production and attraction rates are avoided. However, these data are not sensitive to changes in production and attraction that may result from implementation of some freight policy. This is overcome by aggregating all origins or destinations for each commodity in every zone, providing respectively, general production or attraction levels for each commodity. Production and attraction figures, rather than origin-destination pairs, allow flexibility in addressing the effects of freight policy on industry production, industry or public consumption, as well as transport logistics decisions.

Mode split determination and traffic assignment are performed simultaneously. The multimodal network provides two transportation choices (rail or truck) and allows the intermodal movement between these two. The network is attributed with modal rates (\$ per ton-mile). Thus, by assigning traffic to the minimum cost path, which may consist of rail, highway, and/or intermodal transfers, the shipper objective of minimized logistics cost for each movement is achieved. This research thus assumes that mode split is incorporated in the minimized cost objective.

Each commodity group, by nature of its attributes, has different transportation requirements. Shippers base freight transportation decisions on both market conditions and commodity attributes; therefore, shippers of similar goods will have similar transportation requirements. It is also assumed that freight movements of different commodities interact independently with the transportation system. Therefore, this research approach separately models each commodity in individual layers, with each layer representing goods moved by a specific industry or economic sector. After developing the layers for each economic sector, these

layers can be overlaid to result in a comprehensive summary of state-level freight transportation flows.

To effectively address freight policy planning concerns, the model technique not only must provide a baseline estimate of freight flows, but also be sensitive to policy and infrastructure changes. Policy changes usually have the effect of changing modal transportation costs. This may in turn alter trip distribution, and ultimately, industry production and consumption levels. Changing the link costs on the network, specific to mode, reflects changes in transportation costs for each mode as a result of the policy. Altering the model's network representation can simulate infrastructure changes. Links can be added to the multimodal network, if a new facility is constructed, or link attributes can be changed, if an existing facility is modified.

The procedures outlined above are summarized in the following steps, and are illustrated in Figure 1:

1. Identify commodity tonnage produced or attracted to each zone.
2. Construct a multimodal network representing all feasible routes for freight movements to, from, and within the state.
3. Assign freight flows to the network with the objective of minimizing total logistics cost for each movement.
4. Calibrate and validate the resulting traffic assignment with other data sources.
5. Incorporate policy effects in the network or production/attraction estimates.

### ***Commodity Flow Data***

Commodity flow movements are available in the Transearch database provided by Reebie Associates (Stamford, CT). Information provided in the Transearch data includes origin state, origin BEA, destination state, and destination BEA – for each origin-destination pairing. The data are further classified by Standard Industrial Commodity (SIC) code and volume of freight by shipping mode in short tons (2,000 lbs.). Transearch data as purchased by the Iowa DOT shows only those movements with origins and/or destinations within Iowa, and does not include bridge traffic through the state.

Construction of the Transearch database uses several primary sources of data, as outlined in the Transearch Reference Manual. A partial list includes: 1) Railroad Waybill Sample,

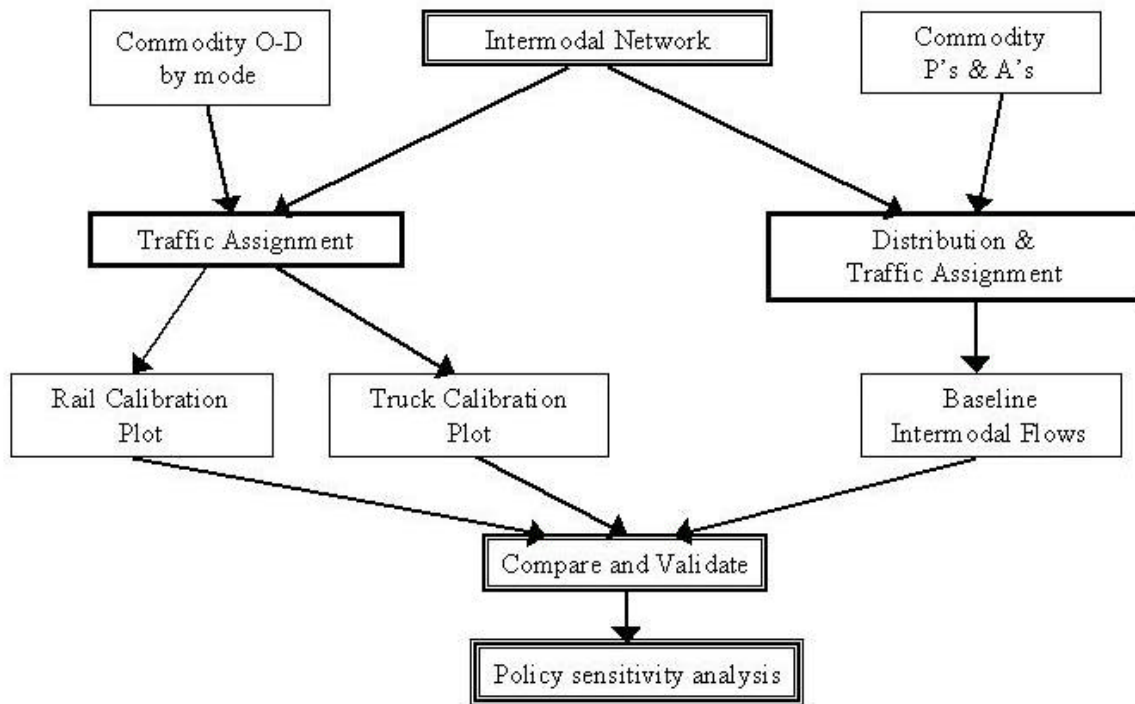


Figure 1. Modeling Methodology

2) Commodity Flow Survey, 3) U.S. Census Survey of Manufactures, 4) annual motor carrier industry financial and operating statistics, 5) annual county employment and population data, and 6) actual truckload traffic flow data as reported by major truckload motor carriers. These data are then converted into the common Transearch framework, while ensuring the elimination of any potential double counting from partially overlapping data sources.

These data were produced in 1992, therefore, all other model assumptions and data sources should be based around this date, to provide accuracy of model results for that base year. As used in this model process, employment and population statistics, as well as truck and rail freight rates, are based on 1991 or 1992 data.

For this model development, the Transearch data were imported to a MapInfo table (see MapInfo User's Guide for importing text data). This file has been named REEBIE92.TAB, and has the following structure:

REEBIE92.TAB File Structure

Column Name	Type	Description
ORIGSTATE	Small Integer	Origin State for shipment
ORIGBEA	Small Integer	Origin BEA for shipment
DESTSTATE	Small Integer	Destination State for shipment
DESTBEA	Small Integer	Destination BEA for shipment
COMMODITY	Small Integer	SIC Code, 3 digit
RAILCONTTON	Integer	Rail tons in container
RAILBULKTON	Integer	Rail tons by bulk
RAILINTER	Integer	Rail tons by intermodal
HIRECONTTON	Integer	Truck tons by for-hire carrier in container
HIREBULKTON	Integer	Truck tons by for-hire carrier in bulk
LTLTON	Integer	Truck tons by LTL
PRIVCONTTON	Integer	Truck tons by private carrier in container
PRIVBULKTON	Integer	Truck tons by private carrier in bulk
AIRTON	Integer	Airborne freight tons
H2OCONTTON	Integer	Waterborne freight tons in container
H2OBULKTON	Integer	Waterborne freight tons in bulk
TOTVALUE	Integer	Estimated total value of all shipments in \$\$
TOTWEIGHT	Integer	Estimated total weight of all shipments

For purposes of the model, a commodity flow text file is necessary that includes only the rail and truck tons. This text file is prepared as follows ({###} is replaced by an integer number for SIC of modeled commodity):

```
SQL select (QUERY > SQL SELECT) :
Origstate, Origbea, Deststate, Destbea, Railcontton, Railbulkton, Railinter, Hirecontton,
Hirebulkton, Ltlton, Privcontton, Privbulkton from Reebie92 where Commodity = {###}
into 'temp'.
```

Export 'temp' to REEB###.TXT text file (TABLE > EXPORT).

The FORTRAN program REEBIE.EXE proportions the commodity flow data to the zonal structure, as described in the following section.

### ***Zonal Structure***

The first step in this model development is to define regions representing the traffic analysis zones (TAZ). Measures of travel demand are aggregated to these zones. The zonal structure of the provided Reebie Transearch database defines a beginning geographic level of aggregation. For Iowa and its neighboring states, the Business Economic Area (BEA) is the smallest zone at which data are presented. Further from Iowa, states and combinations of states, become the zonal level of data aggregation.

For detailed analysis of freight flows within the state, the level of aggregation at which these data are presented is insufficient. Iowa data are aggregated to the BEA level, providing only four complete zones and several partial zones within the state boundaries. For freight flows in Iowa, the 99 counties are logical TAZ definitions. The number of routes within this area is minimized to a few primary highways and railroad branch lines. This method provided a total of 144 zones (99 counties in addition to 45 external zones).

Data as provided in the larger BEA format for Iowa must be disaggregated to the smaller county level. Production and attraction estimates, and origin-destination pairs from the BEA level are proportioned to the county level according to the contribution by that county. Data disaggregation for originating freight observes the following underlying premises, as stated in NCHRP Report 260, Application of Statewide Freight Demand Forecasting Techniques:

1. Manufacturing plant output is correlated with the number of employees.
2. All plants in same industry (i.e. same commodity group) have equal productivity.
3. All plants in same industry share proportionately in resulting commodity flows.

Thus, for a given commodity movement originating in Iowa, data aggregated at the BEA level can be apportioned to a county level by using county and BEA employment data for the relevant industry:

$$\text{County Origin Tons} = \text{BEA Origin Tons} \bullet [\text{County Employment} / \text{BEA Employment}]$$

Likewise, attractions must also be disaggregated to the county TAZ level. An input-output table could be used if that commodity is distributed to other various manufacturing industries or directly to consumers. Commodities that are assumed to be final products are distributed directly to the consumer, avoiding an input-output analysis. For this model development, the latter point is observed, and as a result, trips destined to Iowa are proportioned according to a measure of consumption for that commodity as follows:

**County Destination Tons = BEA Destination Tons • [County Consumption / BEA Consumption]**

Measures of consumption are specific to the industry or commodity group. For example, with Meat Products (SIC 201), a region's population is assumed to identify the demand for meat products in that region. As another example, for Farm and Garden Machinery (SIC 352), the farmed acreage in each county is assumed to describe the demand for that commodity.

Manipulation of county and BEA GIS coverages provided the TAZ map for this model. This table, TAZ.TAB, is formatted in the following manner:

TAZ.TAB File Structure

<b>Column Name</b>	<b>Type</b>	<b>Description</b>
FIPS	Small Integer	State FIPS code of TAZ (or Reebie region)
BEA	Small Integer	BEA code of TAZ (or Reebie region)
TAZ_ID	Integer	TAZ code (1-99 for Iowa counties)
emp_ratio201	Float	County employ. / BEA employ., for SIC 201
emp_ratio352	Float	County employ. / BEA employ. , for SIC 352
pop_ratio	Float	County population / BEA population
Farm_ratio	Float	County farmland / BEA farmland
Population	Integer	County population (Iowa counties only)
pop_bea	Integer	BEA population
Co_farm_land	Integer	County farmland (Iowa counties only)
BEA_farm	Integer	BEA farmland
SIC10 through SIC390	Integer	Industry employment (Iowa counties only)
BEA_201	Integer	Industry employment in BEA for SIC 201
BEA_352	Integer	Industry employment in BEA for SIC 352

Statewide economic and demographic data for population, employment, and other industry statistics, are available from several government agencies. At the county level, detailed, confidential employment data by industry are obtained from the Iowa Department of Workforce Development (IDWD), observing confidentiality agreements. Population statistics are publicly available from the U.S. Census Bureau. Agricultural statistics, including farmed acreage in each county, are available from the U.S. Department of Agriculture.

For purposes of the model, a text file of TAZ data is necessary for each commodity to be modeled. This text file is prepared as follows ({###} is replaced by an integer number for SIC of modeled commodity, and farm\_ratio [for SIC 352] would replace pop\_ratio [for SIC 201]):

SQL select (QUERY > SQL SELECT) :

FIPS, BEA, TAZ\_ID, emp\_ratio###, pop\_ratio (or farm\_ratio);

Order by TAZ\_ID into 'temp'.

NOTE: It is important that the results of the query be ordered by TAZ\_ID for purposes of the data disaggregation program.

Export 'temp' to TAZ###.TXT text file (TABLE > EXPORT)

The FORTRAN program REEBIE.EXE performs the data disaggregation and prepares the commodity trip table for TRANPLAN computer modeling and analysis. The data are arranged to the requirements of TRANPLAN (production-attraction data: Models—Page 1-7; origin-destination trip table: Matrix Utilities—Page 6-2.)

Data for each TAZ are condensed to one location, a centroid node. For each zone, centroids are closely placed geographically to the center of economic activity for that TAZ. These economic hubs were located for this model using GIS data sets from the Bureau of Transportation Statistics (BTS) for large urbanized areas, as well as U.S. Census data for smaller population centers in Iowa counties. Points are placed on a GIS map, and attributed with the appropriate TAZ code (1-99 for Iowa counties, 100-144 for every other zone).

### ***Highway Network Definition***

The Iowa primary roadway system is used to represent the network available to truck movements within Iowa. This classification includes all interstate, U.S., and State highways. Beyond Iowa boundaries, the network can be thinned to essential routes that would primarily be used in long-distance freight movements, such as the interstate system. It can be assumed that for long distance hauls, trucks will be attracted to the high-speed, access-controlled interstate system. Also, it can be assumed that within a short distance from state borders, trucks will try to access the interstate system by way of primary highways in adjacent states.

As a result, the highway network used in this study includes all primary roadways within Iowa, select principal highways in neighboring states, and interstate highways throughout. The primary system within Iowa is available as a GIS coverage in its most current, updated version from the Iowa DOT. Interstate highways and principal highways in neighboring states are

identified through the National Highway Planning Network GIS coverage included in the BTS National Transportation Atlas Database (NTAD). This highway network is constructed in a file separate from the railroads, but will be joined together, as described later.

Each centroid of each TAZ is connected to the highway network. The primary highway system allows sufficient access to each county from several directions. Centroid connectors are directed from the centroid node to one or more adjacent highways.

### ***Highway Network Attributes***

Transport of commodities on the highway network, by way of truck transport, has a certain associated charge per ton-mile assessed to the shipper. This cost of transportation varies by commodity, often dictated by time-sensitivity and packaging requirements. Therefore, for this modeling process, cost of truck transport on a highway link was assumed to be a function of distance. This rate is not included in the network attributes, but is calculated in the TRANPLAN execution, as described in later steps.

The GIS network developed for this model is attributed according to the TRANPLAN network requirements (Networks—Links: Page 1-10, Section 6; Nodes: Page 1-9, Section 4b). Node coordinates for ANODE and BNODE are attained from GIS. A MapBasic program ID\_NOD.MB creates a table of nodes and assigns the anode-bnode combination to each network link. This same program also finds the distance of each link, as needed for the LINK DISTANCE field in TRANPLAN. For ASSIGNMENT GROUP or LINK GROUP, the value '1', is given to the highway network.

Other attributes are included that are not necessary for TRANPLAN. Classification of the roadway (Interstate, CIN, all others), as well as speed limit, are user-defined values that might be useful for later analysis.

### ***Railroad Network Definition***

The network of railroads within Iowa consists of all currently active rail facilities. Beyond Iowa boundaries, this network can be thinned to mainline routes of major railroad operators, as smaller operators will not usually intercept movements of long-distance rail hauls.

The railroad network for the entire nation is available in GIS format in the BTS National Transportation Atlas Database, at scales of 1:100,000, or 1:2,000,000. This model utilizes the

1:2mil scale, with reported traffic levels from an unknown time period classifying these rail lines as mainline and branch line.

Within Iowa, the railroad network consists of all rail lines in the BTS data set that correspond to those lines present in the 1992 Iowa Railroad Service Map from the DOT. From these maps and discussions with DOT planners, it is evident that many Iowa rail facilities in the BTS map had long ago been removed from service (abandoned or rail banked). Thus, the BTS data could not be used directly in Iowa without modification and forensic analysis.

Outside of Iowa borders, the mainline tracks of several major railroad operators are included in the rail network. Of all the nationally operating, Class 1 railroad companies, only those that operate within Iowa are included in this network. These selected railroad operators include Burlington Northern-Santa Fe Railway (BNSF), Union Pacific Railroad (UP), CSX Transportation (CSX), and Norfolk Southern Railway Company (NS). System maps available from these companies through the Internet allow identification of the rail network not in Iowa. These map images are imported into GIS, registered as raster images, which gives them an accurate geographic position. Using these raster maps beneath the BTS mainline railroads, rail network links were digitized for these carriers along the identified routes. Including smaller operators within Iowa, a total of eight railroad companies are included in this rail network. Using this number of railroad operators provided a geographically dense coverage for a railroad network reaching all TAZs.

Not every centroid for each TAZ is connected to the rail network. This is only observed in Iowa, where rail availability in each county is determined by the existence of a rail line within that region. In addition, each industry group within that TAZ may not have access to that rail link. This latter point is ignored in this study, as it is assumed that where a rail line exists in that zone, it is also accessible to each industry in that zone.

### ***Railroad Network Assumptions***

Railroad mergers after 1992 are reflected in this network's railroad operator attribute. Comparing the 1992 Rail Service Map to the 1997 Rail Service Map, both provided by the DOT, the only changes observed between the two include the mergers of Chicago Northwestern with Union Pacific, and the switch from Soo to IMRL. However, these changes should not affect the

model, which uses 1992 data, since rail density and the associated, assumed service quality, have not changed in that time period.

In meetings with Iowa DOT planning experts, it was stated that Class 1 railroad operators are not likely to transfer shipments to or from other major railroad operators at locations other than large freight hubs. At other locations, these major carriers may transfer loads with smaller Class 1 or Class 2 operators, if the larger operator does not service the points of origin or destination, and a classification yard exists there for those two operators. To simulate these assumptions, specific locations were selected throughout the network where inter-operator transfers are permissible.

These inter-operator exchanges are coded as turn penalties for the purposes of modeling. Movement from one operator's facility, through an exchange point, to another operator's facility, is penalized a specific \$/ton value. This table exists as TRANSFRS.TAB, a MapInfo table of the node combinations that comprise the penalized movement. The transfer nodes included in this table should be located on the rail network to investigate how inter-operator transfers were depicted. Once all exchange points are identified and entered in a table, SQL queries can be performed to achieve the from-through-to combinations necessary for the transfer penalty table. This table is used later in the modeling program, exported to a text file meeting the TRANPLAN requirements (Paths—Page 1-3).

In a given TAZ with an existing rail line, rail transport may not be accessible for every industry in that zone. This fact is ignored in this modeling process, as time constraints and data availability discouraged collection of these network attributes. Should TAZ industry rail access be ascertained, industries without access would likely be coded as turn prohibitors, similar to those constructed above.

### ***Railroad Network Attributes***

Shippers transporting commodities on the railway network are assessed a certain charge per ton-mile. Like truck transport rates, this cost of transportation varies by commodity, often affected by bulk quantity, time-sensitivity, and packaging requirements. Cost of rail transport on this network representation is also assumed to be a function of distance. This figure, like truck transport rates, will vary by commodity, shipment size, and car type.

The GIS network developed for this model is attributed similarly to the highway network – according to the TRANPLAN network requirements (Networks—Links: Page 1-10, Section 6; Nodes: Page 1-9, Section 4b). The MapBasic program ID\_NOD.MB, as with the highway network, performs the same GIS functions for the rail network. For ASSIGNMENT GROUP or LINK GROUP, the value ‘2’, is given to the highway network.

Other attributes are included that are not necessary for TRANPLAN. Classification of the rail facilities (Class 1 through 4, as specified by Rail Operating Speeds), as well as rail operator, are user-defined values that might be useful for later analysis.

### ***Intermodal Transfer Definition***

The transportation system represented in this study is multimodal, reflecting the behavior of various interactions between rail and truck modes. Intermodal transfers between rail and truck will occur only at specific locations in the system. These locations, operating as intermodal terminals, have the equipment and facilities available to efficiently transfer shipments between these two modes. Rail intermodality includes a broad range of services; the most common are 1) trailer-on-flatcar (TOFC), also commonly referred to as “piggyback”, 2) container-on-flatcar (COFC), 3) double-stack train (DST), and 4) carless technologies. For the purposes of this study, an intermodal movement of any kind may occur at a designated intermodal transfer.

Intermodal terminals for this transportation network are located from the GIS TOFC/COFC coverage in the BTS NTAD. There are 367 locations given in the original table. Selecting those locations that are specifically noted in the data as being operated by one of the eight selected railroad operators provided a smaller list. Next, this list was narrowed further to one transfer point per operator in each TAZ. The only exception to this selection criterion is Memphis, Tennessee, a known, high-volume intermodal transfer location for the selected four, nationally operating, Class 1 railroad operators (Birmingham, AL is the other intermodal terminal located in this TAZ). All intermodal terminals included in the NTAD database within Iowa are included in this network. This elimination process left 55 intermodal terminals remaining.

The two networks of rail and highway are joined only at these intermodal connections points. For each intermodal facility, the nearest rail line coinciding with that intermodal operator is located and spliced. Intermodal connectors are then drawn from this rail line and connected to

the nearest primary highway. These intermodal connectors are drawn and added in the railroad network, constructed separately from the highway network. However, to make these connections, rail lines and highway links are spliced separately (alternating between editable layers). The individual network, after all splicing and intermodal connections are completed, is then run through ID\_NOD.MBX, to obtain nodes and coordinates.

### ***Intermodal Transfer Attributes***

Revenue charges for intermodal transfers are incurred when carriers transfer shipments through these terminals. Relative to the costs associated with transport by rail or truck alone, typical costs per ton are associated for a freight transfer through an intermodal facility. This rate will vary by commodity and type of intermodal movement.

These intermodal transfers are coded as turn penalties for the purposes of modeling. Movements from a rail facility, through an intermodal facility, to a highway route, (and vice-versa) are penalized a specific \$/ton value. This table exists as IMTRNSFR.TAB, a MapInfo table of the node combinations that comprise the penalized movement. The transfer nodes included in this table should be located on the multimodal (rail/highway) network to investigate how intermodal transfers were depicted. Once all rail-intermodal points are identified and entered in a table, SQL queries can be performed to achieve the from-through-to combinations necessary for the transfer penalty table. This table is used later in the modeling program, exported to a text file meeting the TRANPLAN requirements (Paths—Page 1-3).

### ***Modeling Process***

Following construction of the multimodal network, freight flow simulation can be performed, assisted with computer applications. TRANPLAN software, commercially available for travel demand modeling, was chosen because the Iowa DOT uses this software regularly for its transportation modeling needs.

Other reasons for selecting TRANPLAN for this analysis include the existence of interface programs that allow import and export to the selected MapInfo GIS software, which will be described later. TRANPLAN accepts only text files for description of the node and link network. The program developed for this model, STMOD.MB(X) can generate and export the

required information as input to TRANPLAN. After TRANPLAN has completed its network flow calculations, the output is imported back to the GIS for display and analysis.

The following subsections describe modifications to the UTMS as adapted to this freight modeling application.

### ***Trip Generation***

Trip generation is already present in the commodity flow data. This study combines origins or destinations for each chosen commodity in every zone to provide estimates of productions or attractions, respectively. This process was described earlier in *Commodity Flow Data* and *Zonal Structure* sections. The FORTRAN program REEBIE.EXE creates the necessary input files.

Trip generation rates, typically used in UTMS applications, are avoided in this model. They could be used, following the zonal structure established previously. Text files must adhere to the TRANPLAN requirements (production-attraction data: Models—Page 1-7; origin-destination trip table: Matrix Utilities—Page 6-2.)

### ***Trip Distribution***

Having calculated commodity production and attraction levels, a gravity model of the following form is used in this research:

$$V_{ij} = \frac{P_i \cdot A_j \cdot F_{ij} \cdot K_{ij}}{\sum_x A_x \cdot F_{ix} \cdot K_{ix}}$$

$V_{ij}$  = Volume of freight from zone  $i$  to zone  $j$

$P_i$  = Freight volume produced at zone  $i$

$A_j$  = Freight volume attracted to zone  $j$

$F_{ij}$  = Trip impedance factor from zone  $i$  to zone  $j$

$K_{ij}$  = Interzonal adjustment factor from zone  $i$  to zone  $j$

Several parameters in the gravity model, such as the friction factors ( $F_{ij}$ ) and interzonal adjustment factors ( $K_{ij}$ ), need to be calculated to simulate freight distribution on the transportation network. Following is a discussion of these two variables, and how this methodology will adapt them to freight transportation.

## Friction Factors

For freight transportation, distance or transport cost is typically used instead as a measure of zonal desirability. Following a study performed at the University of Indiana, friction factors are based on the following formulas:

Food and Kindred Products (SIC 20)

$$F_{ij} = e^{-0.0048 * D_{ij}}$$

Machinery, except electrical (SIC 35)

$$F_{ij} = e^{-0.0023 * D_{ij}}$$

where  $D_{ij}$  = travel distance (miles) from origin  $i$  to destination  $j$ .

One limitation of this methodology lies in this distribution process. For freight transportation, shipping rates are probably a more reasonable impedance than cost determined by only by distance. Rail and truck shipping rates based on distance and commodity could be plotted against travel distance to formulate a better friction factor equation. Distribution of freight may not be solely related to distance or cost, as assumed in the gravity model methodology. Long-standing relationships among specific companies, or product differentiation between companies, may also play a role in the distribution of specific commodities. This latter point could not be reflected in this model process.

Friction factor data, using the above equations, were developed in spreadsheet software. This file is exported to a text file, and manipulated to meet the TRANPLAN requirements (Models—Page 1-7, Section 2) with FF###.TXT.

## K Factors

Another parameter in the gravity model formula is the sector to sector bias factor, or more commonly called the socioeconomic interchange adjustment. The purpose of this variable is to increase or decrease the attractiveness of specific sectors to trip allocation. Since, the Reebie data specifies only those trips with origins and/or destinations in Iowa, the gravity model distribution should not produce trips having both origins and destinations in any zones other than Iowa TAZs. Thus, K-factors of zero are used to prohibit these undesired trips for zones 100-144 (zones 1-99 correspond to the 99 Iowa counties).

K factor adjustments are included with the friction factor data, formatted to the TRANPLAN specifications ((Models—Page 1-8, Section 5).

### ***Mode Split and Traffic Assignment (Combined)***

Modal division follows trip distribution in the sequential, four-step modeling technique. Traffic split among competing modes would then be assigned to the appropriate modal network. Shippers of freight minimize the total cost of shipment, possibly employing several modes to achieve the delivery. In addition, carriers of freight, especially the long-haul trucking companies, may rely on intermodal rail service to complete the line haul transport on time-insensitive commodities.

To address these behaviors of shippers and carriers in mode choice and routing, mode split and traffic assignment have been combined in this research to reflect the intermodal nature of rail and highway freight transportation. Link impedance values for both rail and highway networks reflect typical transport charges, and intermodal connections are attributed with typical transfer charges. Assigning traffic to the shortest path that minimizes transport cost, which may consist of rail, highway, and/or transfer penalties for intermodal and inter-operator transfers, allows an implicit mode split based on the assumed shipper decision-making process.

Traffic is placed on the network using an “all or nothing” assignment. With this method, there is no consideration given to the network link capacity or travel time as affected by congestion. Congestion is usually not a key issue for intercity freight transportation. Freight traffic, especially by truck, is indeed impacted by congestion, but a change in the freight sector usually leads to very small changes in congestion.

TRANPLAN is used to perform the trip distribution and traffic assignment/mode split phases. NETBLD.IN is the TRANPLAN control file for this process.

### ***Model Output***

GIS software is used to display and analyze the results. Model results are included in the network coverage, attributing links with their associated commodity flows. Visually, these volumes can be represented with ‘buffers’, expanded lines whose radii are proportional to the volume of commodity moved on that link. Refer to the MapInfo User’s Guide for buffering instructions.

Other data to be output from the model process is the modal shares of traffic predicted by the gravity model. In aggregating the data to general production and attraction levels, mode split in the data is lost. The results of the model methodology unifying mode split and traffic

assignment can be compared to the modal percentages estimated in the origin-destination commodity flow data, as described in the following section.

### ***Calibration and Validation of Modeling Methodology***

The Transearch database, without modification, is used to determine truck traffic and rail traffic distributions, supplying a check on the distributions predicted with the model. These data specify trip ends (origin and destination), volume, and mode. Thus, trip generation, distribution, and mode split are already performed, and provide a trip table that can be directly assigned. Assignment of this traffic to the network, restricted to a particular mode, will provide truck and rail baseline calibration plots. The model results, using the summed production and attraction data (mode split lost), can be tested against these calibration plots. The resulting accuracy of the mode split results using the combined mode split/traffic assignment technique can be investigated. A modified NETBLD.IN is the TRANPLAN control file for this process.

Model parameters can be revised to bring the modeling discrepancies of the two approaches within a tolerable level. The gravity model equation for trip distribution contains variables, such as the K factor and friction factor, that can be changed to affect the model results. Traffic assignment utilizes link costs and turn penalties, which are coded first with predetermined values for modal transport cost, but can be reevaluated with different freight rates or include link travel time.

To ensure that the model methodology not only replicates the given data, but also the true behavior of the system it represents, validation of model results is performed. Data sources for modal commodity movements other than Transearch provide a system of checks and balances for the model results. The Iowa Truck Weight Survey provides estimates of highway freight flows throughout the state. The 1993 Commodity Flow Survey is often used as the primary data source for commodity flow movements, but is already incorporated in the Transearch database. Specific to rail freight transport, the Rail Carload Waybill Sample could be used to validate annual commodity flow estimates on the railroad and intermodal links; however it too is already a data source to the Transearch database. Thus, the Iowa Truck Weight Survey provides the only readily available, external data source to check the model results.

### ***Policy Sensitivity***

To effectively address freight policy planning concerns, the model process incorporates steps to analyze effects of policy and infrastructure changes. By modifying the model in various ways, three classifications of freight transportation issues can be addressed:

1. Changes in transport cost. The resulting change in transport cost for either mode is an input to the link costs, and freight traffic assignment can be redone to investigate changes in freight flow trends.
2. Changes in production or consumption. Growth factors can be applied to the general production or attraction levels determined from the commodity flow data, and trip distribution redone with the gravity model. Freight traffic is then assigned to the multimodal network to assess the traffic volume changes.
3. Changes in the transportation infrastructure. To represent a new facility, links can be added to the network. If a facility is improved, link costs can be adjusted. Traffic assignment on the new network is then performed to investigate the change in corridor traffic levels.

For specific steps on modifying the model to meet these analysis capabilities, consult the User's Guide that accompanies this document.