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16. Abstract

This report presents the findings of an evaluation of the Department's need for a mode share estimating capability. The report documents the process to develop a standard/basic mathematical model for estimating transit riders in an urban area. The model was developed using data from San Antonio, Texas, and is operational using standard TRANPLAN programs on a personal computer using MS/DOS. This model will serve as the starting point for customizing a transit rider forecasting model for individual urban areas in Texas. The model developed is considered potentially applicable for home based work trips for mid-sized cities, smaller than Dallas and larger than 200,000.

The model is a multinomial logit model based on traditional travel time and cost variables and treats travelers in four income stratifications. The current model structure and computer program estimate only transit riders but are adaptable to estimate High Occupancy Vehicle (HOV) users and the number of vehicles for different carpool sizes. The present model also does not include treatments for persons accessing transit by personal vehicles but could be readily expanded to do so. The model currently operates as a simplification of a nested model, so it can be easily modified to incorporate the above mentioned alternative modes in a nested model structure.

This report describes the rationale for developing a mode share model for the Texas Department of Transportation. It then addresses the decision process that led to selection of the approach described above. Thereafter the data needs and process for obtaining and preparing those data are detailed, along with the procedures followed and results of estimating model coefficients. A users manual for the computer program, including data descriptions, is in the Appendix.

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Dr. Gordon A. Shunk
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Research Report 1478-2F
Research Study Number 0-1478
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Sponsored by
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IMPLEMENTATION STATEMENT

The goal of this project was to recommend and develop a standard mode share model for use by the Texas Department of Transportation (TxDOT) to estimate transit ridership in larger urban areas across the state. The model developed in this project will be useful to TxDOT for conducting multimodal transportation planning studies in urban areas with populations less than one million. This model will provide TxDOT the capability to estimate the influence on transit ridership of conventional roadway and transit improvements. This model also is capable of being enhanced so as to provide estimates of usage of fixed guideway transit and high-occupancy vehicle lanes.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect official views or policies of the Federal Highway Administration or the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation. Additionally, this report is not intended for construction, bidding, or permit purposes. George B. Dresser, Ph.D. is the Principal Investigator for this project.

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SUMMARY

Interviews with TxDOT management and technical staff identified a consensus that true multimodal transportation planning would require developing a mode share model for estimating the potential usage of improved transit. Such a model should be integrated into the existing standard TxDOT scheme of travel forecasting models and should be sufficiently general or adaptable to be used in any Texas urban area, thus, a standard model.

Mode share models for Houston and Dallas/Fort Worth were examined to see if they could be the basis for the standard model. The Dallas/Fort Worth model was determined to be inadequate for this purpose because it used older technology. The Houston model was being revised to include the latest technology available from mode share models developed in other cities. Adapting the Houston model would take advantage of those technical improvements, but work on the Houston model would not be completed in time for direct usage of that new model in this project. It was decided to use a generic form of the Houston model as the basis for the standard model.

The standard model was developed for San Antonio because it was the next largest city in Texas after Houston and Dallas/Fort Worth and likely to need a mode share model for transit planning in the near future. Data from person travel and transit use surveys in San Antonio were used to develop the standard model. Transit network data developed by the VIA transit agency and highway network data developed by TxDOT were also used in the model development process. The model was developed by modifying various coefficients of the generic Houston mode share model. The resulting model is considered adequate to serve as a starting point for estimating total transit ridership. The model equation coefficients would have to be modified to accurately estimate transit ridership in cities other than San Antonio. Further refinement will be necessary to accurately reproduce transit line volumes.

PROBLEM STATEMENT

The metropolitan transportation planning process conducted by the Texas Department of Transportation (TxDOT) until recently has primarily concentrated on planning for new and improved highways. As a result, the travel forecasting process employed by TxDOT, including the travel demand and supply models, has only addressed personal vehicle traffic.

Recently TxDOT has begun to be more involved in developing high-occupancy vehicle (HOV) lanes and transit as options to highway improvements. This is due in part to additional responsibilities assigned to the Department by the legislature and federal law. The federal Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the Clean Air Act Amendments of 1990 (CAAA) mandate consideration of HOV lanes and transit as alternatives to major highway improvements.

Texas urban areas, especially the four areas that have not attained federal air quality standards and the other four Transportation Management Areas (TMAs) have shown increased interest in using HOV lanes and transit to solve their transportation needs.

TxDOT INTERVIEWS

At the start of this project five TxDOT officials, Mr. Mark Yancey, Mr. Alvin Luedecke, Mr. Richard Christie, Mr. Robert Cuellar, and Mr. Zachary Graham, were interviewed to determine their opinions regarding TxDOT responsibilities for multimodal transportation planning. They clearly indicated that TxDOT should have technical capability to conduct analyses of needs for alternative transportation modes and should develop and maintain a mode share estimating capability.

Monitoring expenditures of federal transportation funds is part of the responsibility assigned TxDOT by the federal transportation authorization. To exercise these responsibilities, TxDOT reviews both transit and highway projects in locally developed Transportation Improvement Programs to assure those projects are justified.

Assessing the justification for such projects and the appropriateness of transportation plans requires an understanding of the anticipated use of the proposed facilities and services. For years TxDOT has had the technical capability to assess the need for highway improvements, but new multimodal planning responsibilities under ISTEA require a similar understanding of and capability for evaluating transit projects. To assure coordination of transit and highway planning and to properly consider the relative merits of transit and highways, it is important that transit planning be conducted in a manner consistent with that for highways.

Integration of transit and highway planning is particularly important for assessing the effectiveness of HOV facilities, which accommodate both transit and personal motor vehicles on the same roadway.

TxDOT is responsible for transportation planning technical analysis in most of the state's urban areas, so it will have to forecast the use of such facilities and services in order to determine if the development is warranted. The effectiveness of those solutions will have to be seriously considered before proposals for additional roadway improvements will be accepted.

Currently only Houston and Dallas-Fort Worth, have capability to prepare transit ridership forecasts for use in developing transit plans. That capability in Austin is being improved. Thus it will be necessary for TxDOT to develop such a capability or have the technical planning done by consultants. Because several cities will be needing transit planning, it seems appropriate for TxDOT to develop its own capability if it will continue to provide these services to urban areas. This will require that TxDOT improve its capabilities in order to provide the transit planning technical support for most of the state's Metropolitan Planning Organizations (MPOs).

Having such a capability is also important in order to have state-of-the-practice transportation planning procedures. Procedures at that level of sophistication will almost certainly be required in order to continue receiving federal transportation funds. If the planning process is not adequate to those standards, the state could find itself in legal difficulties for fulfilling requirements of the Clean Air Act and possibly having federal funding cut off until the planning process is updated.

For all of these reasons the Department is considering broadening its travel forecasting procedures to consider the feasibility of HOV and transit and possibly other modes. The opinions expressed in the interviews and the other reasons described above present strong arguments for TxDOT to develop mode share estimating capabilities. The remainder of this report describes the recommended approach for developing a standard mode share model for use in larger Texas urban areas. This report also documents the process and results of developing the standard mode share model.

REPORT ORGANIZATION

The remainder of the report is organized in six major sections and the Appendix. The section following this summarizes the state-of-the-art of mode share models in Texas and recommends actions for developing enhanced mode share analysis capabilities for TxDOT. The third section describes the decision process of model selection and the model development strategy. Following that is a section that describes preparation of the computer program for the model and a section that describes the data processing for model development. The adjustment process for the model coefficients is detailed in the sixth section. Conclusions and recommendation are presented in the final section. The Appendix is a users manual for the computer program that operates the model.

STATUS OF MODE SHARE MODELS IN TEXAS

Mode share models are most often used for estimating the number of person trips in urban areas that will be made by transit. Recent advances with these models in several urban areas also provide estimates of the number of carpools of various sizes that will use HOV lanes. There is considerable experience with these models in the U.S. and other countries, and this was drawn upon when developing the standard model in this project. For use in Texas these models should be developed for three different-sized groups of communities based on needs of those communities related to their sizes: (1) the largest metropolitan areas, with over one million residents; (2) urban areas with populations between 200,000 and approximately one million; and (3) areas with less than 200,000 residents. Different model development strategies are recommended for each size group, and the scheduling of model development actions also differs for each group. Although San Antonio now has more than one million residents, it is recommended for consideration here with the second-tier cities. This recommendation is based on the fact that considerably more extensive model development work is needed for San Antonio because it currently has no trip interchange mode share model, whereas Houston and Dallas-Fort Worth both have operational models that are adequate for at least the near term.

Those models are arguably the most important and most difficult to prepare. They are important because they are necessary to satisfy the new ISTEA and CAAA requirements. They are difficult because they commonly employ rather complex mathematical formulations and development procedures and usually require considerable data about current transit usage. The models developed here will be designed to fit into the regional transportation planning process as currently practiced by TxDOT, providing a new multimodal dimension.

METROPOLITAN AREAS: DALLAS AND HOUSTON

These cities have developed or are developing their own mode share models, and they are undertaking major capital investments in public transportation. TxDOT can learn from both experiences and use that experience for developing other mode share models. It is especially convenient that Dallas has chosen rail and Houston has chosen (largely, to date) HOV lanes.

The experiences of the two cities with those alternative modes will be useful to TxDOT for developing models for other cities that are considering those modes.

Both of the existing mode share models are of the logit form, which is now reasonably standard for mode share models. The Dallas-Fort Worth model is a multinomial model, and the Houston model is nested. Both models adapt experience from the Shirley Highway HOV lane for estimating HOV use. There is reason to be concerned about the fact that the DFW model is not nested. The consultants that developed the DFW model felt that nesting was not justified primarily due to data availability rather than need. The consultant preparing the Houston model has indicated that nesting is appropriate for that model. (Final estimation of the Houston model has not been completed, and it was in the estimation process that the decision was made to drop nesting from the DFW model. Perhaps the Houston model will ultimately also have no nesting.) The basic logic of nesting seems to recommend it, and that would favor the formulation of the Houston model over the DFW model.

The trip purpose categories (home-based work, home-based non-work, and non-home-based) are consistent for the two models. The Houston consultants intend to stratify their models by income level. The DFW model stratified by the captivity of the travelers; i.e., transit captives and auto captives were treated separately from travelers who actually had a share between auto and transit. The variables representing transit and highway level of service and travel cost were reasonably consistent between the two models.

The strategy recommended for these cities is to initially include the DFW and the final Houston models in the TxDOT transportation planning procedures for forecasting travel for those two areas. Having the models from the two cities in the TxDOT procedures will permit TxDOT to support efforts of both areas as they plan for major transportation investments. This approach will provide TxDOT the ability to prepare independent information about transit travel in the two cities. The availability of these models will also permit TxDOT to estimate, for its own project planning, the demand for HOV facilities and roadway traffic volumes that are consistent with the cities' transit service plans. Finally the information gained from working with these models will be useful in developing other mode share models for the second-tier cities and for airport and seaport access. When resources permit, the two models should be carefully examined and compared in order to decide whether one or the other should be the standard used by TxDOT for first-tier cities.

LARGE CITIES: AUSTIN, CORPUS CHRISTI, EL PASO, FORT WORTH, SAN ANTONIO, MCALLEN, ETC.

These cities all have urbanized area populations greater than 200,000 so they are designated TMA by the ISTEA. (Fort Worth is part of the Dallas-Fort Worth TMA but would otherwise be a TMA in its own right.) That designation requires using a state-of-the-practice planning process to develop a multimodal transportation plan. A state-of-the-practice transportation planning modeling system for cities of this size would usually require having a mode share model capability. The cities in this group currently have moderately large fixed-route bus systems and may someday have either HOV or rail transit services. Mode share models would be useful for planning bus services but are virtually mandatory for Major Investment Studies planning rail or HOV facilities.

Useful information about how ridership responds to reasonably good bus service can probably be learned by obtaining boarding counts or transit rider survey data for these cities. In lieu of desirable survey data, comparisons and generalizations between cities will suffice temporarily for developing mode share models.

Austin has a mode share model that was developed using coefficients and constants from an early Houston model and validated against a survey of transit riders. That model represents an appropriate approach for situations where little if any local data are available. The model is probably adequate for bus route planning but may not be satisfactory for planning major capital improvements in public transportation or for satisfying requirements for multimodal transportation alternatives analysis. More detailed analysis is necessary to determine the nature and degree of its deficiencies, if any. If there are significant problems with the Austin model, they may be remedied with additional data to be collected in Austin or perhaps already available in other second-tier cities.

The mode share model currently used for Fort Worth was developed for separate application in both Dallas and Fort Worth. Because of the domination of that model by Dallas data and conditions, it is recommended that a separate mode share model be prepared for Fort Worth as part of the treatment for the second-tier cities. The differences between the two cities have always been recognized, but political considerations and federal regulatory requirements (for regional planning) required use of a joint model. At various times the model was even partitioned to effectively function differently for Fort Worth than for Dallas.

The procedure currently used for mode share analysis in San Antonio is a trip generation model that estimates the number of transit person trip productions and attractions in each zone and then connects trip productions to attractions using a trip distribution model. Such an approach is not satisfactory for considering the feasibility of major transportation improvements such as light rail or HOV lanes. Information on the mode share estimating capability for El Paso and Corpus Christi is vague and contradictory. It does not appear that current capabilities and data available in those cities provide sufficient basis on which to build improved procedures.

A generalized mode share model should be developed for the second-tier cities. The structure of the model should be the same for all cities, but values of the parameters and constants may vary if validation in individual cities indicates it is necessary. The logit form is recommended because it permits dealing with different levels of carpool occupancy, which is necessary for HOV planning. Further, nested logit models are currently the state of the art for mode share models. The model should include level of service and cost variables that are standard factors influencing mode share.

Development of mode share models for these second-tier cities is probably the most important single task in this recommendation. That is because provisions of the new ISTEA require a technically proficient mode share analysis as part of the TMA cities' consideration of alternatives to building roads. It is possible that approval for new roads could be withheld until a satisfactory mode share analysis is completed to demonstrate that non-highway solutions are neither justified by usage nor necessary for improving air quality.

SMALLER CITIES AND RURAL AREAS

A standard mode share model should be developed for the smaller cities and rural areas since TxDOT will probably have to assist these areas in planning transit service improvements. A trip generation (or trip end) mode share model similar to the one currently used in San Antonio would be satisfactory for these areas unless major capital transit or HOV facilities or a radical reorientation of transit services are being considered. Most of the people using transit in these areas are likely to be captive riders who have no real share of travel mode and whose use of transit is probably not influenced much by changes in level of service. The trip end mode share model is commonly a set of equations relating transit trip propensity to socioeconomic and other characteristics of the travelers and may include locational, development, and other physical conditions. This approach permits assessment of the transit trip-generating potential of new development or areas where there is no current transit service. The trip end model estimates trips to and from all travel zones, and the resulting trip ends are distributed using a transit trip distribution model that is similar to the person trip distribution model but is separately calibrated for transit trips. Another option for the much smaller cities and rural areas that have transit service, if little new development is expected, is to use growth factors. Growth factors would be calculated for all travel zones and the Fratar method of "iterative proportional fitting" would be used to modify the existing transit trip table. The growth (or reduction) factors would be computed as the ratios of the population of new to existing transit users. Because of the variety of conditions across the state, both trip generation and growth factor procedures should be developed. Mode share models of these types have been used in many small cities and rural areas outside Texas, so experience in those locations will provide useful guidance for developing models for Texas.

There is no specific mandate for early action to prepare transit service plans for smaller cities and rural areas, but planning activities for the statewide multimodal transportation plan required by ISTEA will consider alternatives to highways. Because that work may require transit ridership estimates, a standard mode share model or other ridership estimating procedure should be developed for these areas. Work on this model should take second priority to work on the model for the TMAs and should benefit from experience from those efforts. Development of procedures for the smaller cities and rural areas should be pursued as soon as possible after completion of the model for the large cities.

PROJECT OBJECTIVE

The assessment of conditions and needs for mode share models described previously in this report was presented to TxDOT in a working paper with a recommendation that development of a standard mode share model for application in the large cities proceed. That recommendation was approved by TxDOT, and the model development process pursuant to that recommendation is described in the remainder of this report.

The objective of the work approved by TxDOT and described here was to develop an operational mode share model that would serve as the standard approach for transit and HOV travel forecasting for TxDOT transportation planning for the large cities previously so identified. The term "standard" as used here is intended to mean that the model would serve as the common basic structure and starting point for calibrating TxDOT specific mode share models for those individual cities. A further consideration of this model development effort is that it should consider the form of the mode share models being or to be developed for Houston and Dallas-Fort Worth with the possibility of its being adaptable to the form of one or another of those models for sake of consistency. The standard model may also serve as the prototype for mode share models for the smaller cities and possibly even the rural areas.

MODEL PREPARATION

The approach chosen for preparing the standard model was to conduct a case study that included data development, model selection, and model development. The case study would be conducted for one of the "large" Texas cities, for which real data were available, including transit travel and performance measures of that city's transit and highway systems.

San Antonio was chosen as the location for the case study. The principal reason for choosing San Antonio for the case study was that most of the data anticipated to be needed to develop the model were already available from a 1990 home interview survey and a 1990 transit rider survey. At the time of model development work in this project, no other city had a good transit rider survey and trip tables from a recent home interview survey. Good data would have been available for Austin, but Capital Metro was developing its own mode share model.

Several other reasons made the share of San Antonio even more desirable. One reason was because it is the largest city in Texas not having an operational trip interchange mode share model. The trip end mode split model currently used by the VIA transit system is adequate for bus service planning but not for evaluating the feasibility of major capital facility improvements. The principal weakness of trip end models is that they do not include effective measures of either transit or roadway levels of service. That is because the level of service for a trip or trip interchange is measured along the path chosen for the trip between the origin and destination of the trip. When using a trip end mode share model, the trip interchange is determined after the new transit trips are estimated, so level of service cannot be effectively considered in the mode share estimation.

Another reason for choosing San Antonio is that operations of the VIA transit system are well managed so it provides a good level of service. What this means is that the transit rider is more likely to be presented with a serious competitor to roadway travel.

Using San Antonio for the case study will be beneficial to the MPO and the transit operator because it will give them a head start on developing an operational mode share model for their use. The model resulting from this project will contribute to improving the area's transportation planning capability; and because of its size, San Antonio may be the next Texas city to consider building either HOV lanes or rail transit and, therefore, is in need of the procedures to be developed in this project.

THE LOGIT MODEL

The model form selected for the San Antonio case study is the logit function. This form was selected because there is considerable experience with it for mode share forecasting, and it has performed well in previous applications. It is currently recognized as the state of the art in transit rider forecasting.

The logit is a probability function that has been demonstrated to accurately represent consumer shares, given attributes of the available alternatives from which to choose. The basic form of the logit model is:

$$P_i = \frac{e^{u_i}}{\sum_k e^{u_i}}$$

where:

P_i is the probability of choosing mode i,

u_i is a function of the attributes of mode **i** (u is commonly called disutility of travel),

e is the base of natural logarithms,

k is the number of available alternative modes, and

$u_i = a_i + b_i x_i + c_i y_i + d_i z_i + f_i n.....$

where:

a_i is a derived constant for mode i that represents various other factors that may not be quantifiable but that are at least implicitly considered by the traveler in the mode selection process,

x_i, y_i, and z_i are variables describing various attributes of mode I, and

n represents one or more factors such as income that may affect mode share

b_i, c_i, d_i, and f_I are coefficients of the respective variables.

The variables commonly represent:

- level of service, such as travel time and distance,
- socioeconomic characteristics, such as income, and
- cost or other characteristics affecting mode share.

The coefficients are determined in the model development process either by statistical analysis or by adapting coefficients used successfully in mode share models for other, similar urban areas.

The equations for computing transit and highway disutility are:

Transit Disutility = $a_t + b_t$ (transit in-vehicle time) + c_t (transit out-of-vehicle time) + d_t (fare) + f_t n

Highway Disutility = $a_h + b_h$ (highway in-vehicle time) + c_h (highway out-of-vehicle time) + d_h (highway operating cost + parking cost) + f_h n

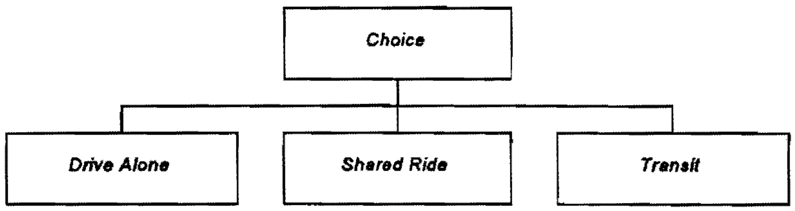
The logit model is commonly applied in either of two ways, depending on various circumstances. The **multinomial** logit model (Figure 1A) assumes that the alternatives from which to choose are independent of one another and compete "equally" to be chosen. The choice between driving alone, carpooling, walking to transit, and driving to transit occurs simultaneously. (This does not mean that there is equal probability that each mode can be chosen. The probability is still based on the previously described computation.) Depending on the available options, that simultaneous choice among those options may not be independent. The occasional lack of independence between choices with the multinomial logit formulation is why it has been criticized in some mode share model applications. In this case, independence means that there is no relationship between choices; e.g., transit is a totally independent choice from driving, but any given size of carpool is not independent from driving alone, since driving alone is a size of carpool. The multinomial model is commonly used when the choice set is reasonably simple, e.g., the alternatives being only walk to transit and personal vehicle trips. Typically this situation occurs when transit ridership is low and/or the data base for transit is weak or when little carpooling is observed. The Dallas-Fort Worth model is a multinomial logit model because of a weak database.

A **nested** logit model addresses the possibility that a hierarchy of choice may occur in the selection of travel mode, and the model deals with choices in stages rather than simultaneously. The nested logit model recommended in previous Texas Transportation Institute (TTI) work[1] for Houston has three levels of choice or nesting (See Figure 1B). The traveler first decides whether to use transit or travel by personal vehicle. The transit selection is then followed by a decision whether to walk or drive to the transit stop. The personal vehicle selection is followed by a decision whether to drive alone or share the ride. If ride sharing was the selection, a final decision would be the size of carpool. The separate decision levels are attractive statistically because they increase the independence between the choice probabilities.

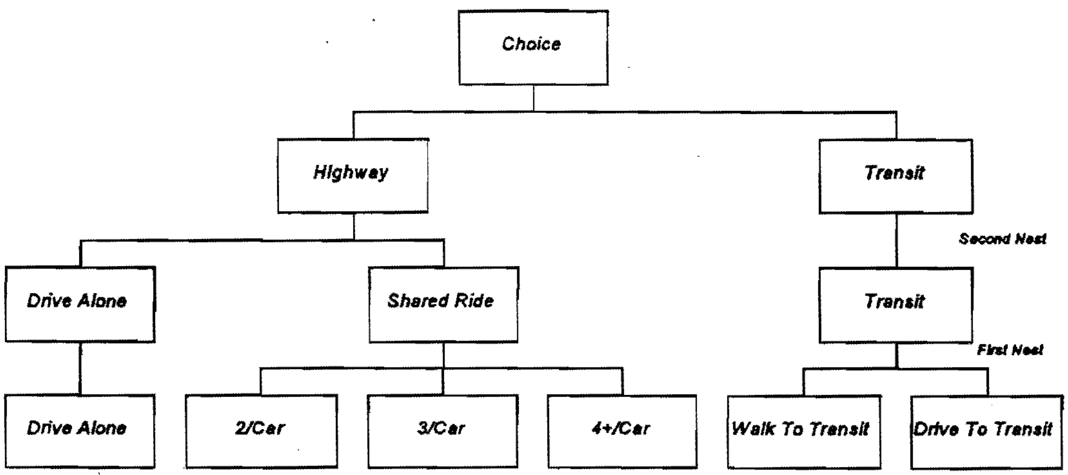
These nesting levels permit identifying the potential use of HOV lanes at different levels of ride sharing. For transit they help to determine if, where, and how much park-ride facilities should be provided. A nested model was recommended for Houston based on exhaustive analysis of many, complex transit and HOV lane usage alternatives in the Shirley Highway corridor in the Washington, D.C., area[2].

A nested model could not be developed for San Antonio today because data are insufficient on which to base the model for persons driving to park-and-ride transit. There are also insufficient data with which to develop the HOV side of the model. This is not presently a problem since San Antonio is not expected to be considering an HOV lane soon. Therefore, a multinomial model would be adequate for currently anticipated applications in San Antonio. This is true for most of the other cities in Texas with the possible exception of Austin. If San Antonio were to desire to investigate the feasibility of HOV lanes or fixed guideway transit, a multinomial logit model would be inadequate.

Figure 1
Optional Logit Structures



1 A Multinomial Logit Model



1 B Nested Logit Model

For developing the TxDOT standard model, the following approach was selected. The standard model was developed as a multinomial model but as a special case of a nested model. That is, the standard model was formulated as a nested model, but all computations except those for the multinomial model were ignored. The model was applied with a computer program for a nested model; but because the nested model computations were bypassed, the program functioned as a multinomial model. This approach provides TxDOT with the flexibility of using the standard model as a multinomial model for most current applications but with the ability to readily revise the formulation whenever the application requires a nested model. For most multimodal planning for Texas cities, the multinomial model is satisfactory, but the enhancements of the nested model can be added if fixed-route transit or HOV lanes are to be considered.

It must be emphasized, however, that the conversion from the multinomial standard model to a specialized nested model is not trivial. That conversion requires estimating the coefficients for the nested model, either using survey data for the area being planned or by importing coefficients in the manner described below.

IMPORTING THE MODEL

The standard model was developed by "importing" a model form and coefficients recommended for Houston[1]. Importing a model means that a structure similar to an existing model is adopted for the model being developed. Coefficients from the existing model are the starting point for a trial-and-error process to adjust those coefficients until the model satisfactorily reproduces the existing trip pattern.

The principal reason for importing a model was to incorporate in the standard model the desirable characteristics of the Houston model. It was expected that the Houston model would have strong capabilities for estimating both HOV and transit usage. Houston has more HOV facilities operating than any other location, and TTI has collected extensive data for those HOV operations. Those situations could be expected to produce the best HOV usage model yet developed anywhere. The transit side of the Houston model was good, too, based on extensive bus service with both express routes and driving access to transit. Another reason for importing the Houston model was for all the Texas mode share models to be consistent, thereby limiting the learning and familiarity necessary to use the models and having more extensive experience with the operation of the models.

Originally, it was intended to import a new mode share model being developed for Houston. Unfortunately the model development work for Houston was not satisfactorily completed before termination of this project. The transit work for the new Houston model was successfully concluded, but the HOV estimating capability was not satisfactorily validated. This presented a quandary of how to proceed with the standard model. It was decided to import the model **originally recommended** for Houston in previous TTI work[1]. The recommendation of that model for Houston had been based on extensive research on HOV demand and transit ridership[2]. The appropriateness of the recommended coefficients was established by comparing them to coefficients for other cities[1]. It was reasoned that the new Houston model, when completed, would be sufficiently similar to the model originally recommended and that only minor revisions would be necessary.

When the HOV portion of the model currently being developed for Houston is validated satisfactorily, the coefficients from that model should be imported for use in the standard model. The flexibility of the standard model permits its use for transit forecasting until valid HOV coefficients are available.

It is important to emphasize that using the standard model in any particular urban area would require adjusting the coefficients in the basic model to satisfactorily reproduce transit travel patterns in that urban area, much as the gravity model is calibrated for trip distribution. That process would require detailed information about actual transit users and their trips, usually available only from a transit rider survey. Transit rider information needed for the standard model would include income level, access and egress modes and travel times, and trip purpose. Calibrating the HOV coefficients of the model would require detailed information on persons traveling in personal vehicles and their carpooling propensity, commonly obtained only from a home interview travel survey. Other information would include whether the traveler was the driver or a passenger, the number of vehicle occupants, the income level of each, and trip purpose.

The model developed here was for home-based work trips. For actual applications, special models would have to be developed for other purposes using the same techniques as used here to estimate coefficients. Mode share models for non-work purposes are commonly developed as modifications of the work trip models or even as factors of the work trip table.

PROGRAM PREPARATION

A computer program for a nested logit model had been prepared as part of the TTI project investigating HOV models for Houston[1]. Only minor adjustments were necessary to adapt that program for handling the standard model. One change was to provide separate input file fare matrices for local and express transit trips. The other was to bypass program processing of carpooling, HOV lanes, and drive access to transit for reasons mentioned previously. The bypassed components were not eliminated from the program and can easily be reactivated when those additional travel options are to be considered. The program and its input and output are described in detail in the users manual in the appendix of this report.

DATA PREPARATION

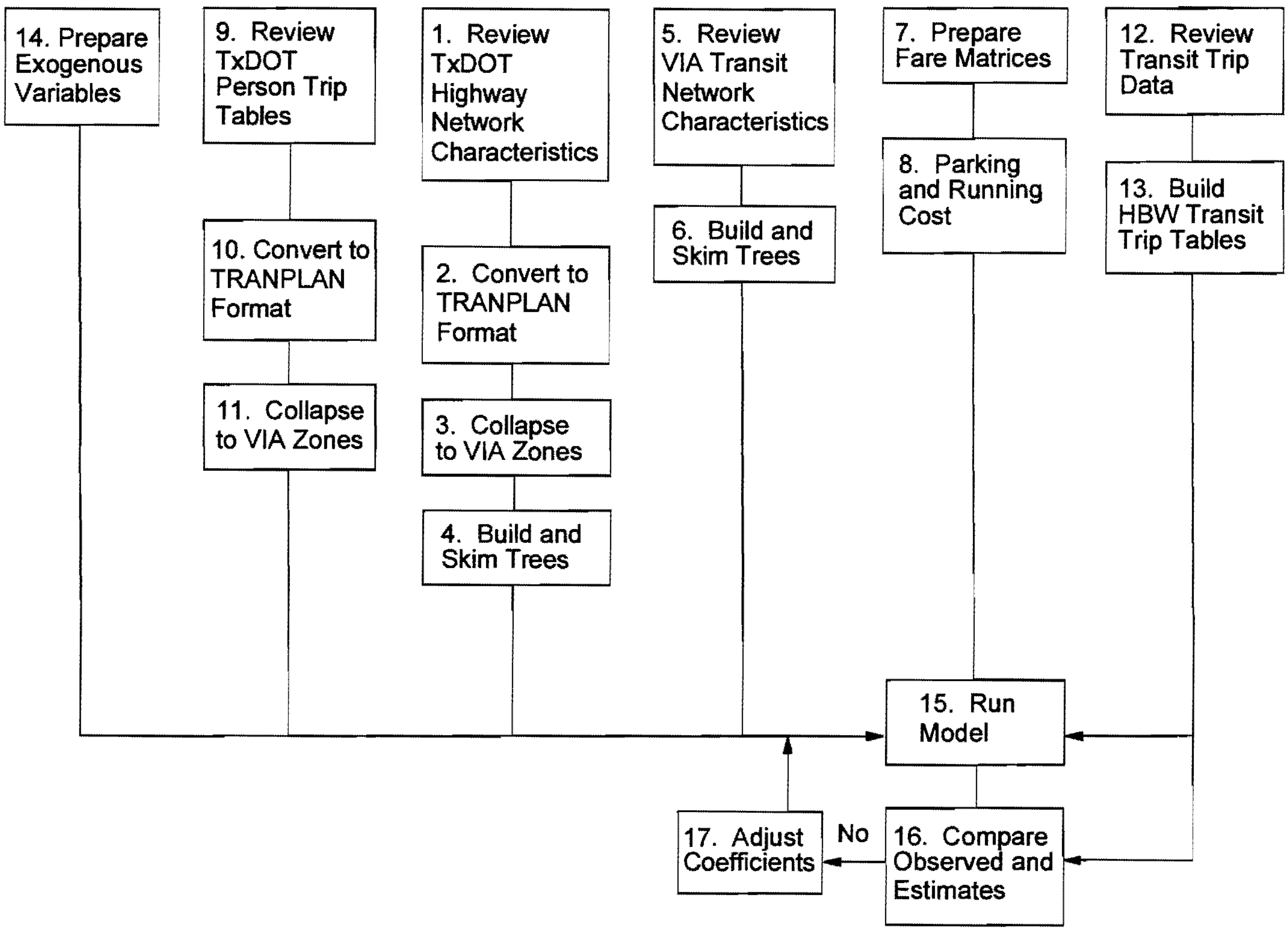
The most difficult part of using a mode share model is preparing the considerable data required by the model and the computer program which operates the model. This was especially true when preparing this model because the data were provided from several different sources and had not been obtained with the intention of developing a mode share model. Those data were coded at different levels of detail and in different formats so they had to be processed for consistency and to meet the requirements of the computer program used for this model. The users manual for the computer program (in the Appendix) describes the data and formats needed both for using the standard (multinomial) model and for the expanded (nested) model that would consider carpooling, HOV lane usage, and/or drive access to transit.

Figure 2 is a flow chart of the data preparation scheme used to prepare the input data for the standard model. The following discussion of data preparation will follow the sequence of numbers in the boxes on that figure.

TxDOT provided the highway network information for this project. The TxDOT highway network connected 817 internal highway zones and external stations. The network was coded with average daily speeds prepared using a capacity restrained traffic assignment. The TxDOT highway zones were combined to match the 197 transit zones in the VIA transit network. Boundaries of the TxDOT and VIA zones were consistent, so the conversion process merely entailed changing the zone numbers on the zone connector links in the highway network. All zone connector links in the highway network were retained so as not to disadvantage the level of service represented in the original TxDOT network.

The resulting highway network link data records were converted to TRANPLAN format and used by the TRANPLAN program Build Highway Network to build a highway network description. A test tree was plotted to verify that the revised network was satisfactory for further processing, and interzonal minimum time path trees were built for all zone pairs with

Figure 2
Data Processing Scheme



TRANPLAN program Build Interzonal Impedances. The resulting trees were skimmed with the TRANPLAN program Highway Selected Summation to obtain interzonal travel times and the distances between zone pairs on the minimum travel time paths.

Data for the transit network connecting 197 zones for the afternoon schedules were provided by VIA and processed with the TRANPLAN program Build Transit Network to obtain a transit network description. A test tree for the transit network was plotted and examined to assure that all coding was satisfactory. The network was then processed with the TRANPLAN program Build Transit Paths to obtain interzonal travel time paths connecting all zones in the network. The TRANPLAN program Transit Selected Summation processed those time paths to identify the five components of interzonal transit travel time for each zone pair connected by the transit network:

- total walking time to and from the transit stop,
- first waiting time for the transit vehicle,
- total time riding on the transit vehicle,
- waiting time to transfer between transit vehicles, and
- the number of transfers required to complete the trip.

These are standard components of mode share models and are routinely provided by the TRANPLAN programs that process transit networks.

The transit network zones in each of the three fare zone areas used by VIA were identified. Connections between all zone pairs were then processed with a utility program to identify the fare that would be charged for trips on each interzonal combination. This yielded a matrix of fares for all possible zonal combinations. This procedure was followed for both regular and express fares to determine the cost of each possible transit trip.

The cost of highway trips was calculated in the mode share computer program by multiplying an average vehicle operating cost (5.8 cents per mile) by the trip distance for each possible trip interchange. This was increased with the parking cost charged in each central business district (CBD) zone. TTI staff determined parking charges in the CBD by conducting a survey in CBD zones. The parking charges for all day parking were weighted by the number of spaces charged at each rate and included weighting spaces provided free by employers.

TxDOT provided 1990 trip tables developed from trip generation models for all-day home-based work person trips, and VIA provided trip records for morning and afternoon transit trips from its 1990 on-board transit rider survey. The TxDOT trip tables were collapsed into the 197 transit zones with the TRANPLAN program Matrix Compress. The VIA trip records were processed with the TRANPLAN program Build Trip Table to prepare morning and afternoon work trip tables. The transit trip tables were then combined to obtain total day transit trips comparable to all-day person trips. The proportion of intrazonal work trips using transit was determined from the VIA on-board survey.

The computer program for the mode share model requires several other items of information, including parameters and a distribution of person trips by income quartile. These are described in more detail in the users manual in the Appendix. One of those parameters is motor vehicle operating cost for which the program default (5.8 cents per mile) was used. Highway network terminal times were estimated from experience, being one minute in all locations except the CBD, where five minutes was used for Zones 1 through 4. The percentage of households in each transit zone in each of four income groups was calculated from census data. These data were readily available because the transit zones are coterminous with census tracts. The Alamo Area Council of Governments estimated the percentage of persons within walking distance to a transit stop for each zone from census data the using their Geographical Information Systems (GIS) system. Information on population stratification by income levels was also prepared by processing census data. The work trip generation rates for each income quartile were prepared by processing data from the San Antonio 1990 home interview survey. The external trips on transit were assumed to be zero; the proportion of external trips by auto drivers was obtained from the home interview survey.

COEFFICIENT ESTIMATION

The computer program for the standard model requires several coefficients that are used in the equations that calculate disutility of traveling by transit and personal vehicle. For the standard model, the coefficients for transit and highway in-vehicle (riding) time and out-of-vehicle (waiting and transfer) times and for transit users by income group are of most interest. The cost coefficient is of minor importance. The fully operational version of the standard model (estimating HOV use, carpooling, and drive access to transit) will require coefficients for calculating disutility for those modes.

The coefficients of interest were adjusted in a trial-and-error manner with the objective of causing the estimated transit trips to match the observed transit trip pattern. The initial coefficient values were those recommended for the Houston model (see previous explanation)[1]. The model program estimated the transit trips with those coefficients, and the resulting estimated transit trips were compared to the observed transit trips. Comparisons were prepared for the numbers of total transit trips and transit trips by income quartile and for the frequency distributions of transit trips versus in-vehicle and out-of-vehicle time. The coefficient for any income category or for in-vehicle or out-of-vehicle time was then adjusted in a manner that would move the number of estimated transit trips closer to the number of observed trips. Decreasing a coefficient would increase the probability of that mode being chosen.

Each coefficient was adjusted systematically in this manner until the estimated trips matched the observed trips as closely as possible for that category or value. After the adjustment of each coefficient was completed, the comparisons for previous coefficient adjustments were checked to see if they were still satisfactory, and they were readjusted as necessary. This process was followed until the comparisons of estimated and observed trips were satisfactory for all categories of income and values of travel time variables.

The first model run displayed considerable disparity between the numbers of estimated and observed transit trips. (Figure 3 is a frequency distribution of the observed and estimated transit trips versus in-vehicle time.) The total number of transit trips being estimated was too high, and the distribution had too many trips by higher income people and too few by lower income people. Table 1 shows the distribution of observed and estimated trips by income group at the start and at two other stages in the coefficient adjustment process. The first coefficients adjusted were for transit riders by income group. The purpose of those adjustments was to influence the distribution of trips among income groups and to more accurately estimate the number of total transit trips. Figure 4 shows the distributions of observed and estimated transit trips by travel time after several iterations of adjustments to the income coefficients. The number and distribution of total transit trips at the same point is shown in the second column of Table 1. Those two displays show that the number of total transit trips and the distribution among income groups improved considerably by adjusting the income coefficients. The distribution of transit trips among income categories compared well with the observed trips. Little additional change was needed, but considerable additional adjustment was still necessary.

Table 1: Texas Standard Mode Share Model
Transit Trips by Income Quartile

	Observed	Initial (1A)	Middle (25)	Final (IV9)
Low Income	12,331	18,199	12,092	15,444
Medium/Low Income	8,786	34,468	8,817	12,051
Medium/High Income	7,442	34,346	7,499	10,228
High Income	5,043	30,561	5,094	7,043
Total	33,602	117,574	33,502	44,766

The next step in the adjustment process was to modify the coefficients for in-vehicle and out-of-vehicle time. The result of several iterations adjusting the in-vehicle time coefficient is shown in Figure 5. The estimated number of trips matched the observed trip pattern quite well for trips with in-vehicle time greater than 14 minutes. Several more adjustments to both in- and out-of-vehicle time produced no further improvement.

Noting that the lines plotted for observed and estimated trips diverged for trips shorter than 15 minutes (in-vehicle time), a regression analysis was conducted of the ratios of observed to estimated trips. The results were surprisingly consistent, with an R^2 of 0.85. A plot of the ratios is displayed in Figure 6, and that consistency shown there suggests a systematic error in estimation process. To accommodate this error the ratio equation resulting from the regression analysis was then incorporated in the model program, which then produced the results shown in Figure 7. This ratio factor also corrected the number of total transit trips

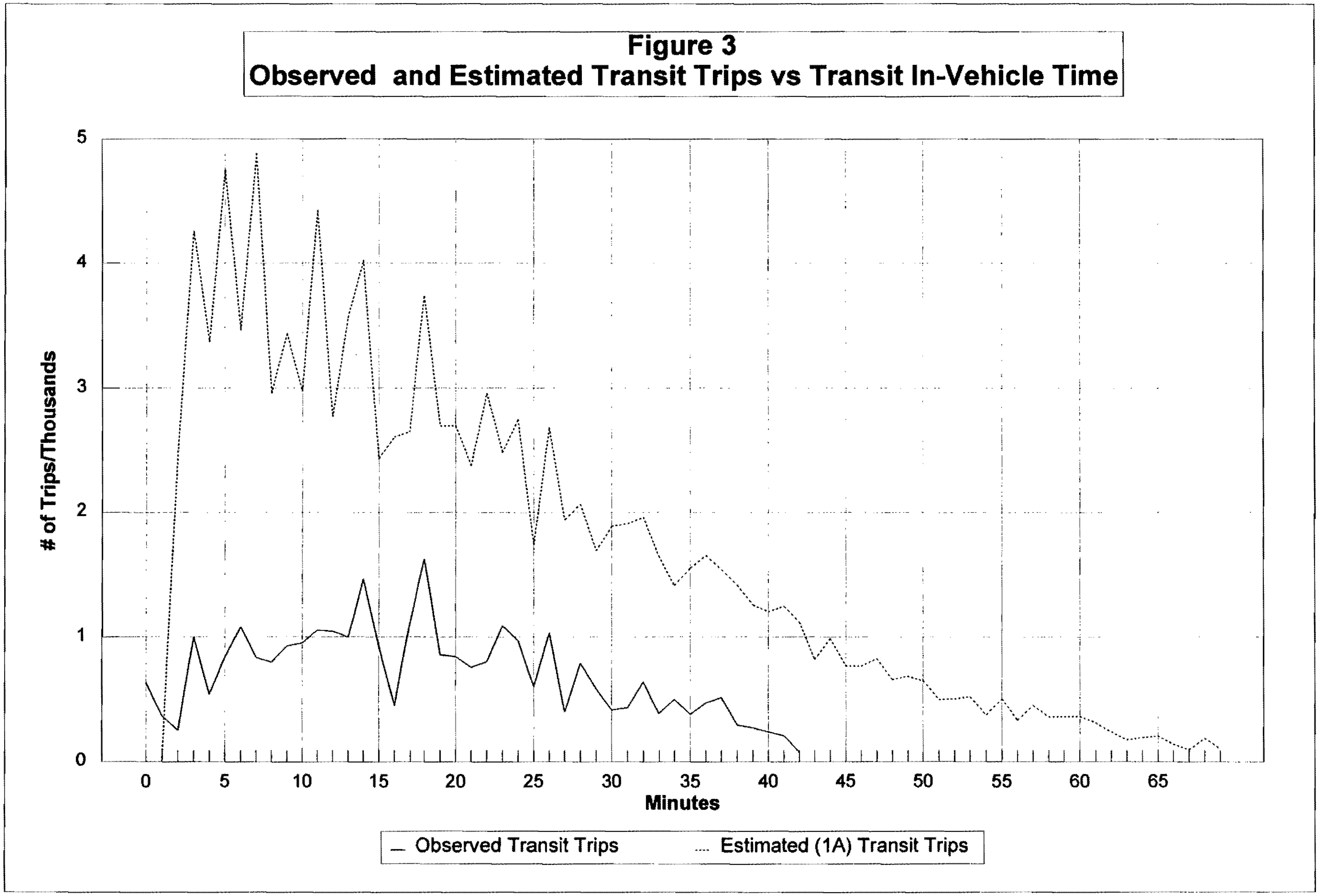
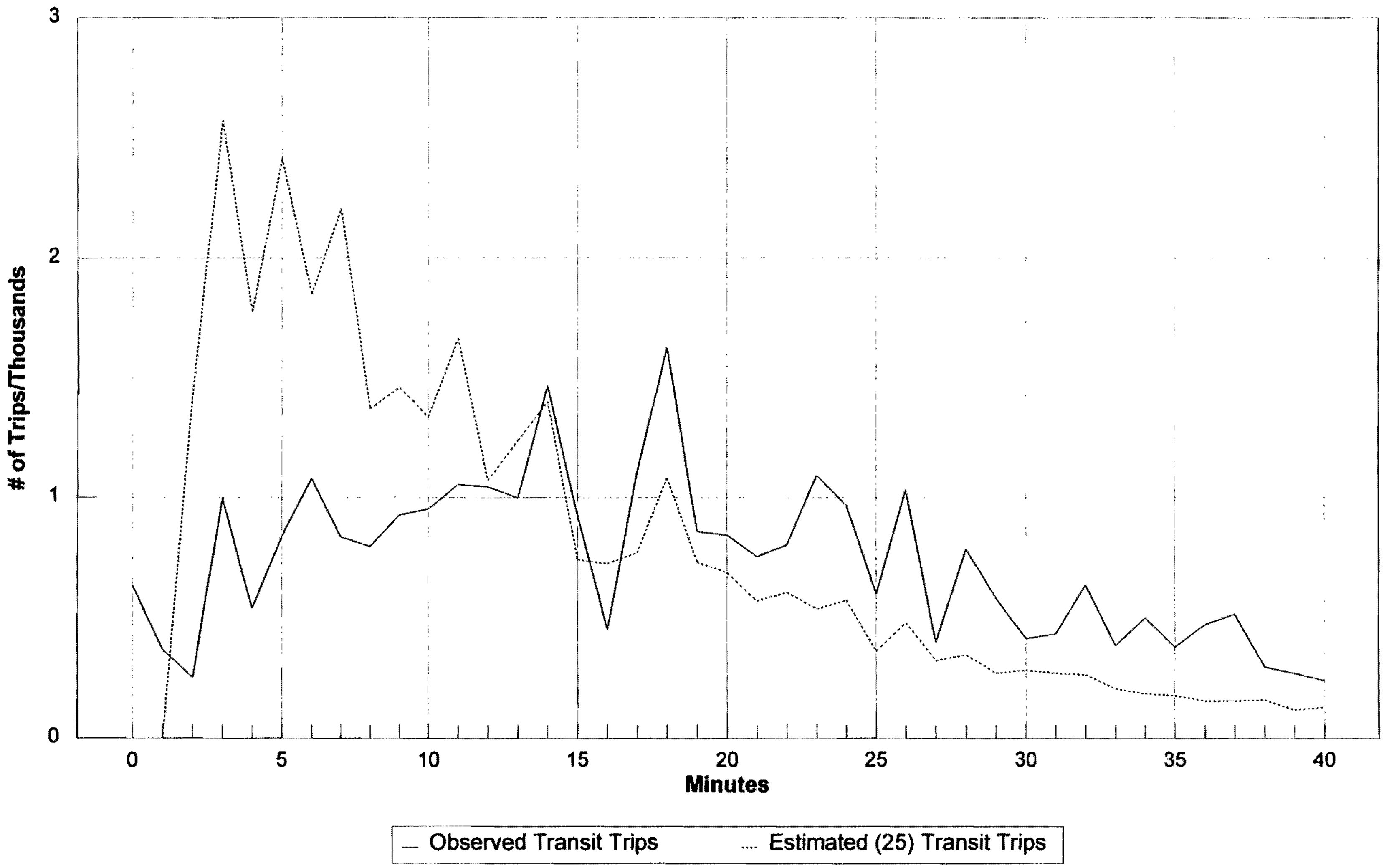


Figure 3
Observed and Estimated Transit Trips vs Transit In-Vehicle Time

Figure 4
Observed and Estimated Transit Trips vs Transit In-Vehicle Time



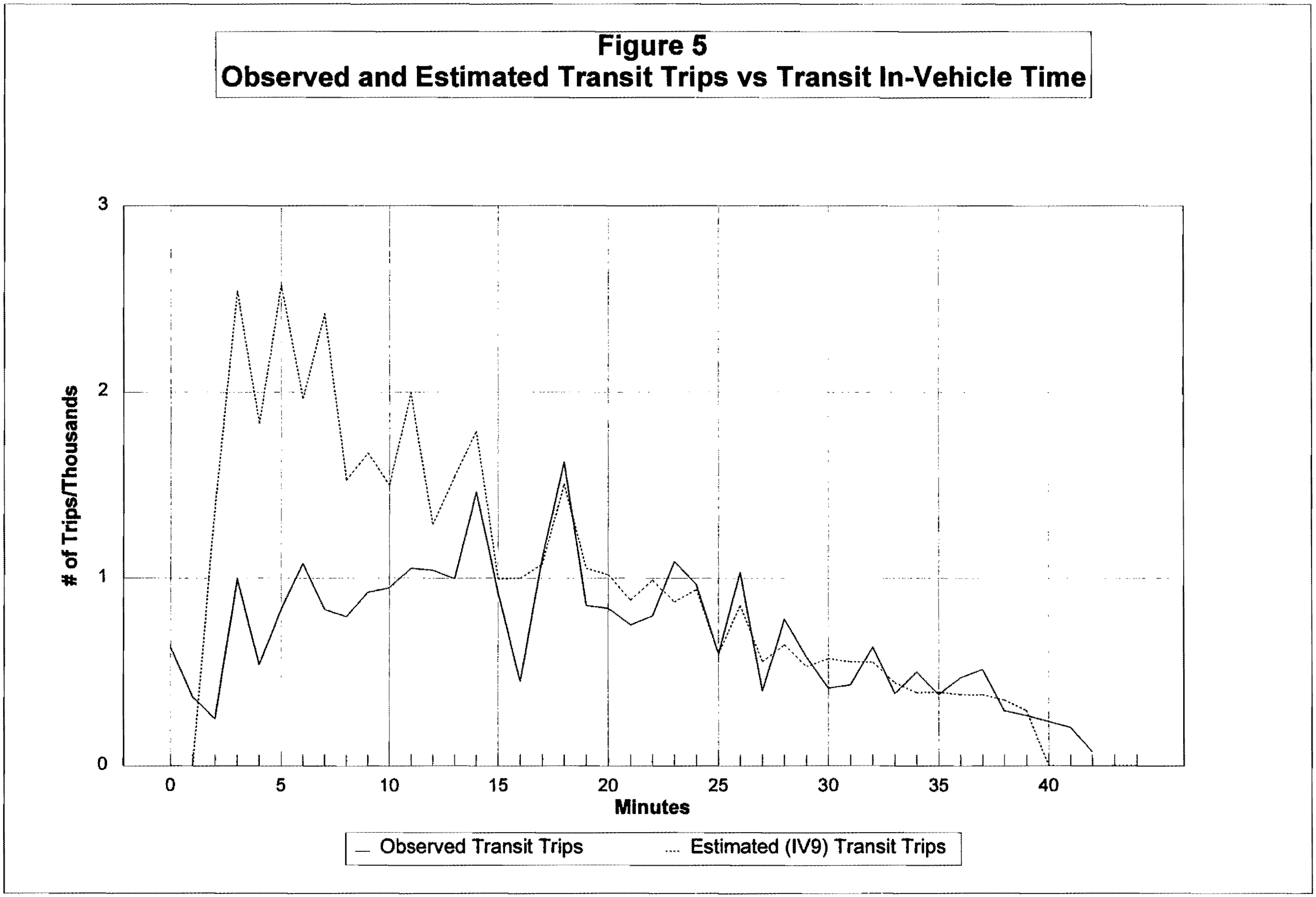


Figure 5
Observed and Estimated Transit Trips vs Transit In-Vehicle Time
3
2
1
0
# of Trips/Thousands
0
5
10
15
20
25
30
35
40
Minutes
Observed Transit Trips
Estimated (IV9) Transit Trips

Figure 6
Ratio of Observed to Estimated Transit Trips vs Transit In-Vehicle Time

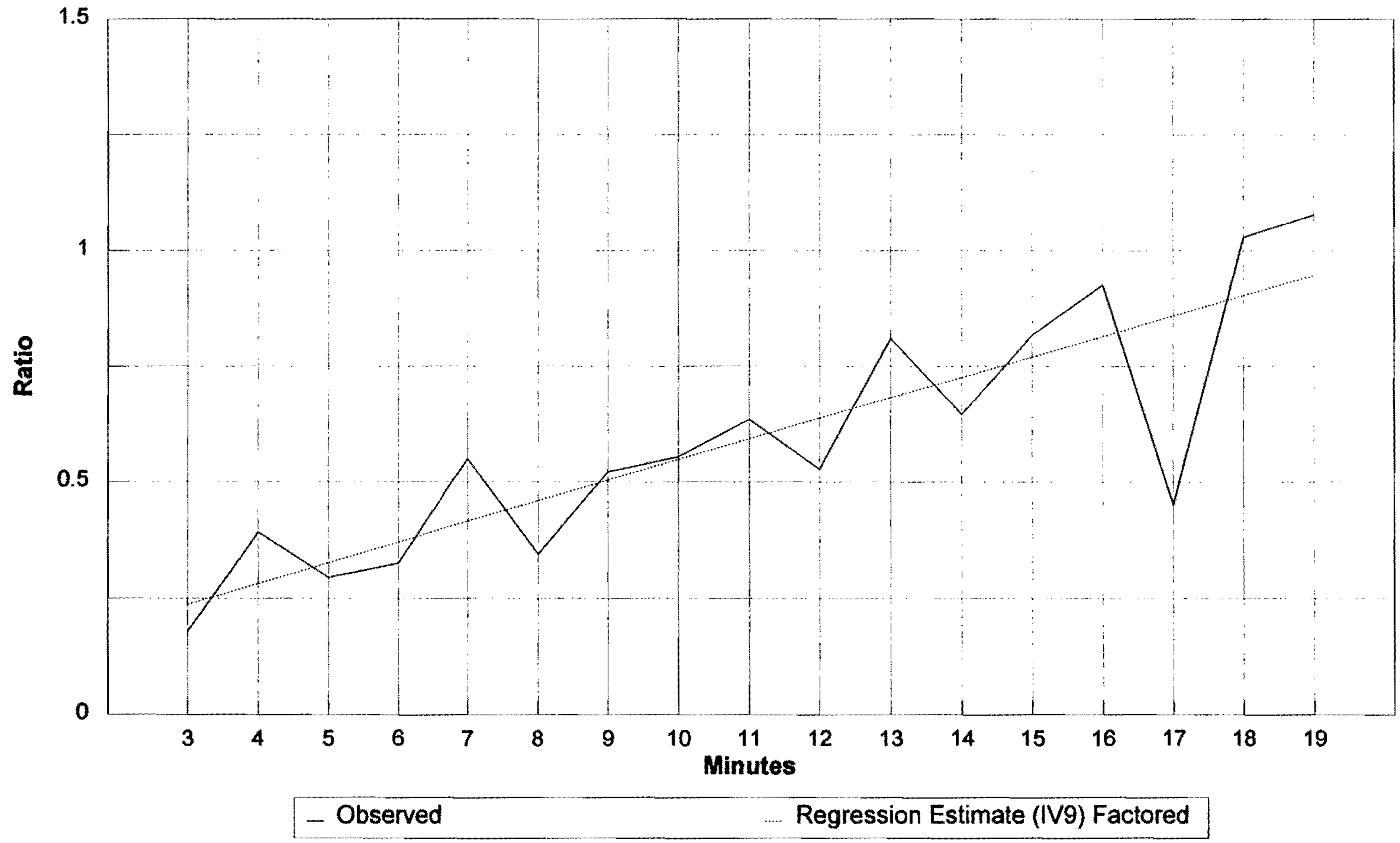
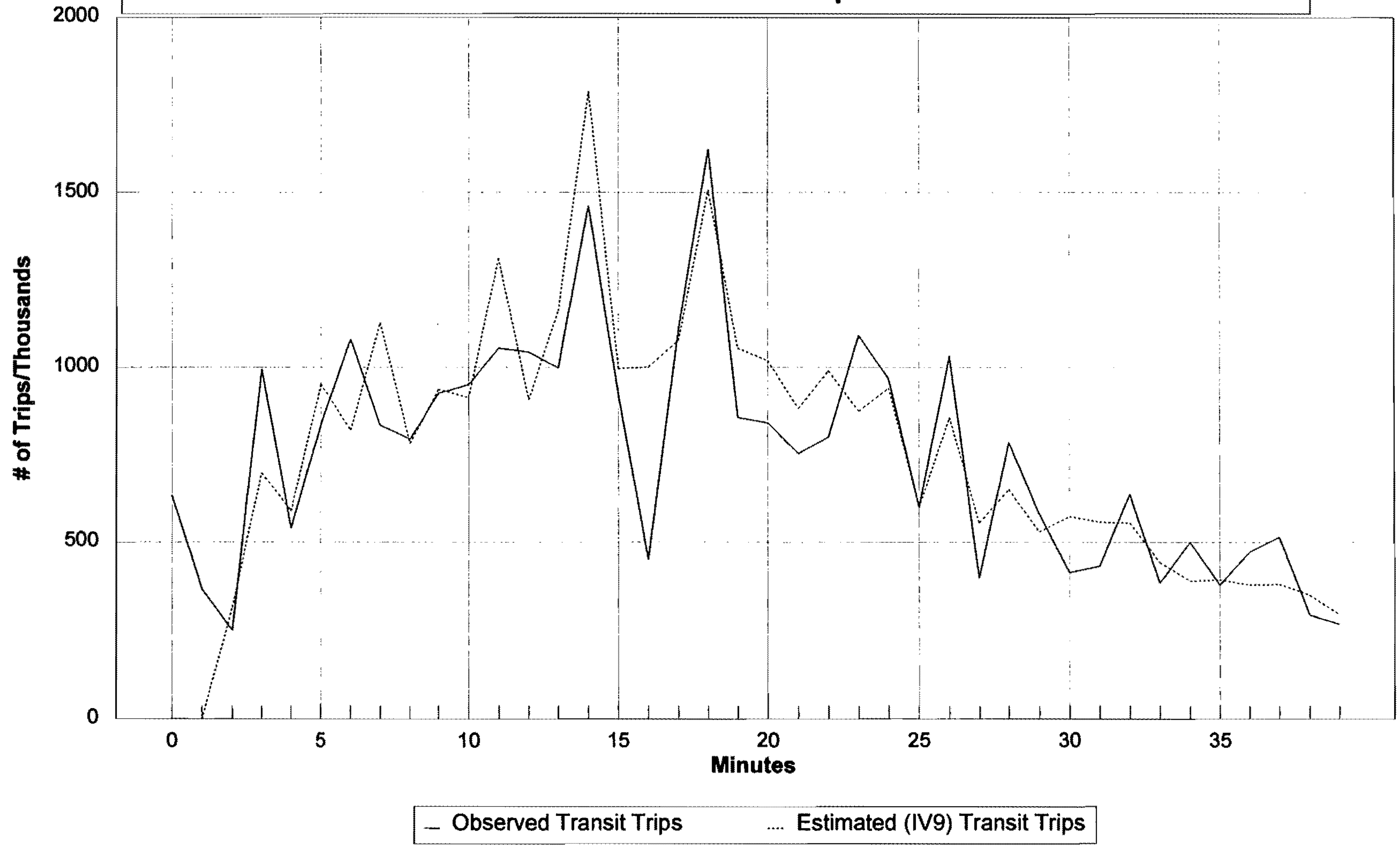


Figure 7

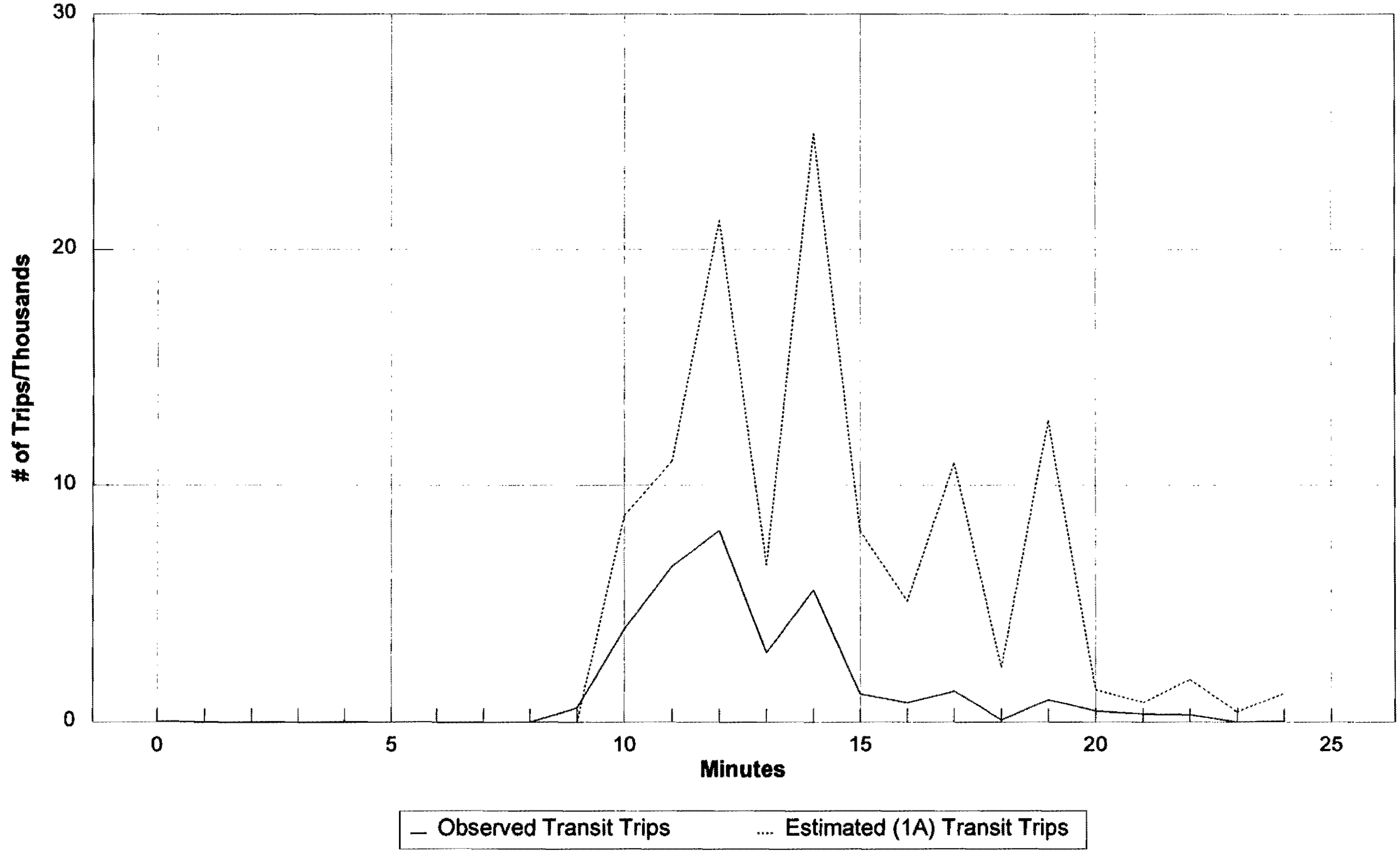
Observed and Modified Estimated Transit Trips vs Transit In-Vehicle Time



and the distribution of transit trips by income level as shown by the figures in the right side column of Table 1. These results were considered adequate to accept the value of the in-vehicle time coefficient at that point.

The next logical adjustment would have been to the out-of-vehicle time coefficient because of the original disparity (before any coefficients were revised) between observed and estimated trips versus out-of-vehicle time as shown in Figure 8. Figure 9 shows how the previously described adjustments to the transit income coefficients had improved the comparison of observed and estimated trips versus out-of-vehicle time. Figure 10 shows how the previous adjustments to the in-vehicle time coefficient had affected the comparison of observed and estimated trips versus out-of-vehicle times. At that point it was decided that the comparison shown in Figure 10 indicated that the model was estimating transit trips with sufficient accuracy to forego adjusting the out-of-vehicle time coefficient. All of the model coefficients, therefore, were considered sufficiently accurate for purposes intended for the standard model, i.e., to demonstrate its functional adequacy as the basis for models to be calibrated for individual urban areas. Therefore no further coefficient adjustments were made, and development of the standard mode share model was concluded.

Figure 8
Observed and Estimated Transit Trips vs Transit Out-Of-Vehicle Time



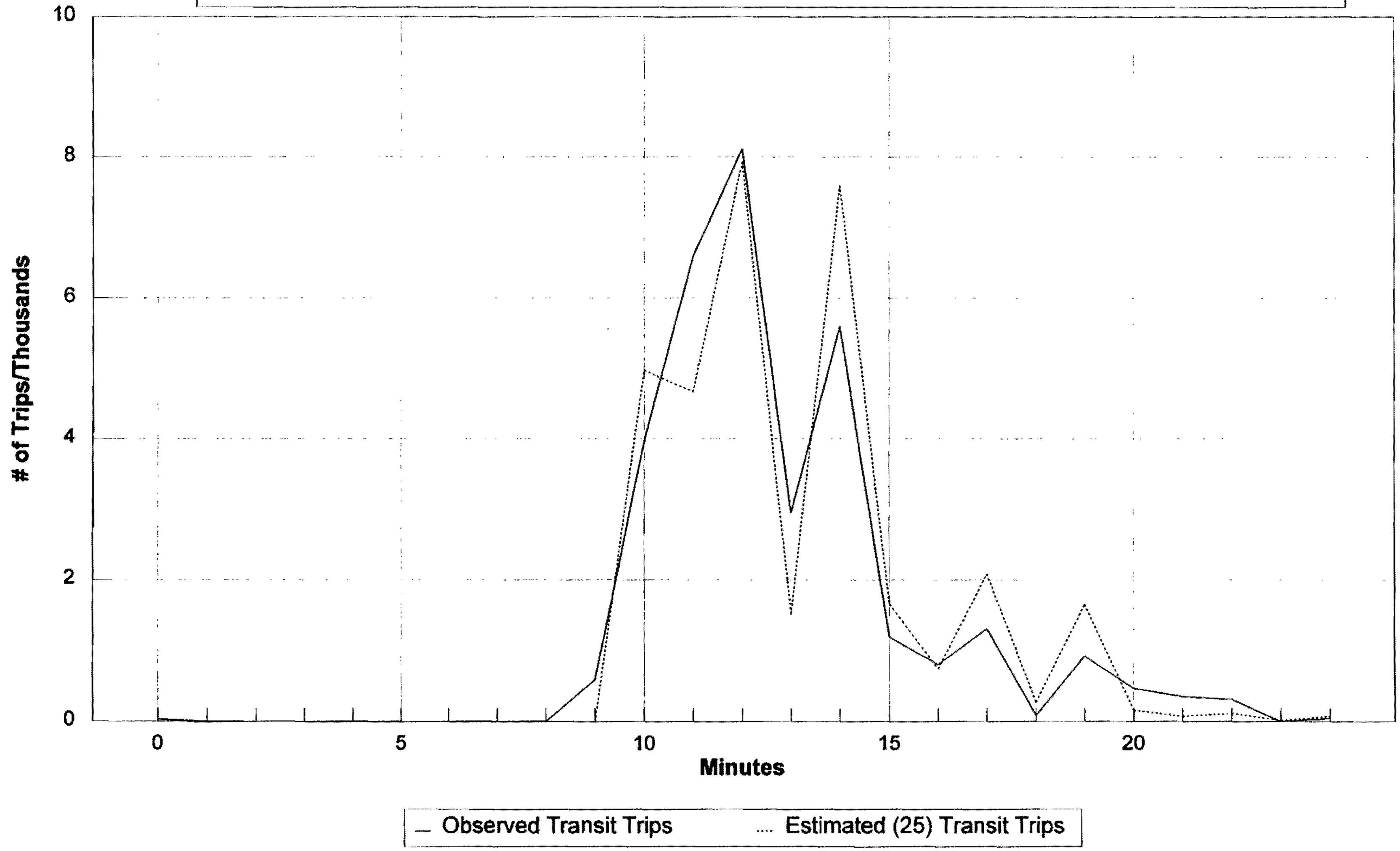
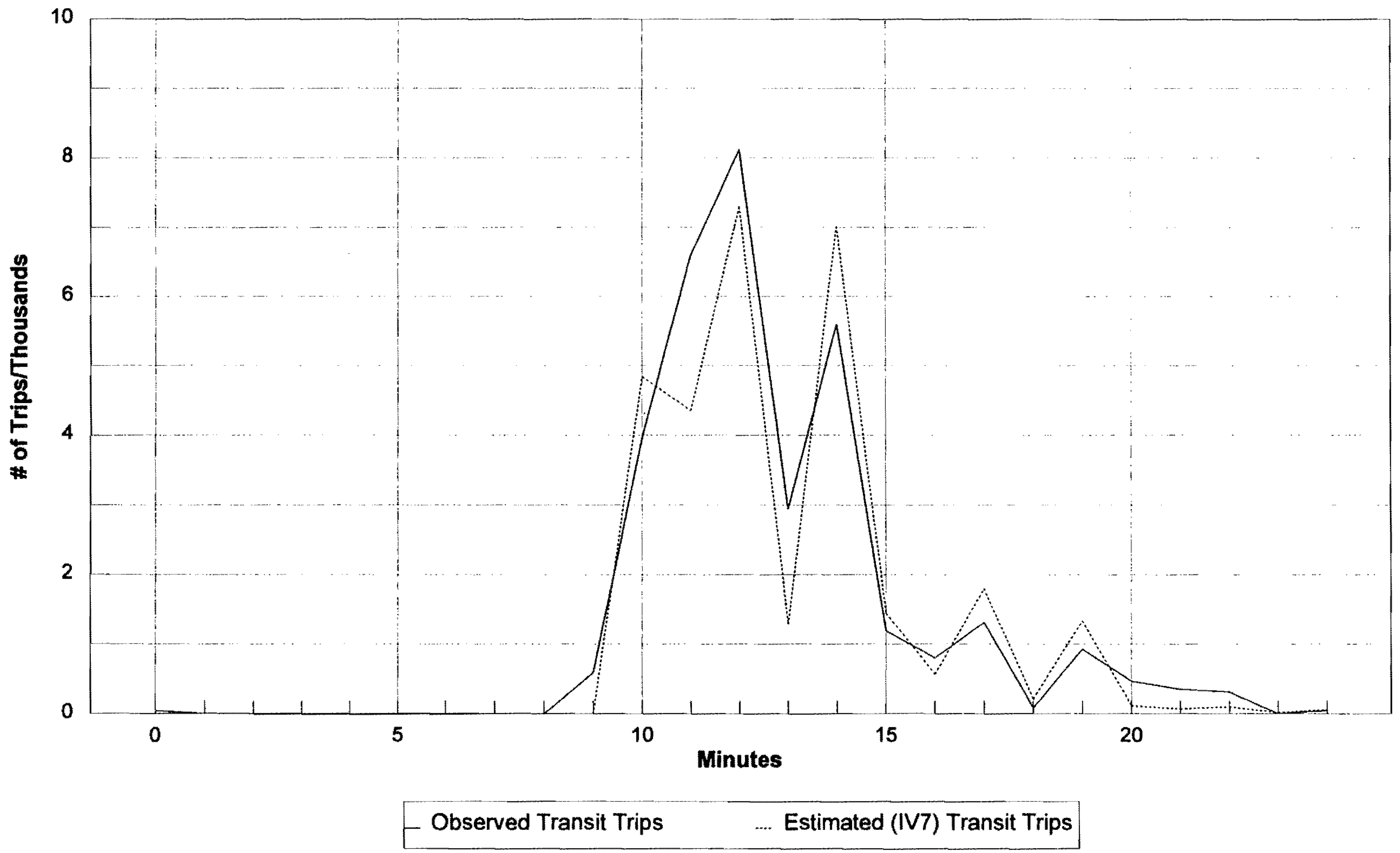


Figure 9
Observed and Estimated Transit Trips vs Transit Out-Of-Vehicle Time

Figure 10
Observed and Estimated Transit Trips vs Transit Out-Of-Vehicle Time



APPLYING THE MODEL

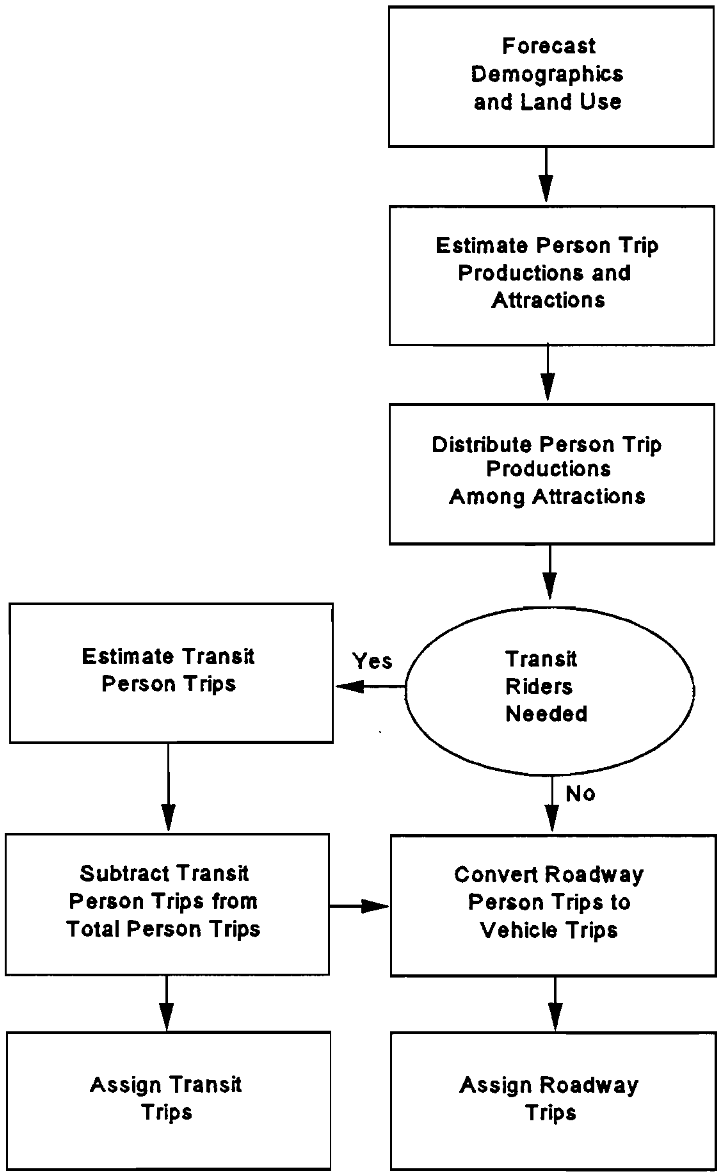
Figure 11 shows how the standard mode share model "fits into" the current TxDOT travel forecasting process. The model is an "off line" function that is used only if an estimate of transit usage is required. Otherwise the highway traffic forecast can be prepared independently of the mode share model. An estimate of transit usage would be required either for planning transit services or adjusting a highway person trip table for expected major effects of transit. The latter situation would occur if there were sufficient transit ridership in the area being planned to significantly influence the accuracy of the estimate of personal vehicle trips. If the mode share model is to be applied, the detailed procedures in the users manual in the appendix to this report should be followed.

A travel forecast using the mode share model would begin as usual with a forecast of demographics and other data needed by the trip generation models. Person trips would then be estimated by the trip generation models, and those person trips would be distributed with the trip distribution model. The resulting total person trips (by purpose) would be a major input to the mode share model. If peak-hour or peak-period transit trips are to be estimated, either the generation model would have to produce trips in that category, or the all-day person trip table from trip distribution would have to be factored for such peak trips.

The highway network processing should include preparing both travel times and distances along the roadway paths connecting all zones. A peak-hour or peak-period network is most desirable for mode share analysis. The table of interzonal travel times and distances by roadway would be converted to TRANPLAN format for processing by the mode share model program.

A network of transit services in the study area, preferably in the peak hour or peak period, would have to be prepared. For each transit route operating in the selected peak hour or peak period, the transit network would have to specify headways between transit vehicles, where vehicles stop to pick up and drop off passengers, the access mode (walking or personal vehicle) to and from the transit stop, and the fare charged to ride each kind transit service. All of this network information is needed by the mode share model computer program.

Figure 11
Travel Forecasting Process



Other data required by the model would include parking costs and a distribution of household by income quartile. The latter could be obtained from the census.

The mode share model would estimate the number of transit person trips expected on each interzonal interchange, producing a trip table of transit trips. Those transit trips could be assigned to the transit network for transit planning purposes. The interzonal transit trips should be subtracted from the interzonal person trips for further roadway trip processing. The resulting trip table would be converted from TRANPLAN format to TxDOT package format for further processing of roadway trips.

The interzonal roadway person trips would then be divided by vehicle occupancy factors in much the same manner as done now to determine the number of personal vehicle trips expected. The vehicle trips would then be assigned to the roadway network for purposes of roadway planning.

ENDNOTES

1. "Consideration of the Applicability of the Shirley Highway HOV Demand Model for Houston," Texas Transportation Institute; College Station, Texas; 1995.

2. "Models of Mode- and Occupancy-Choice in the Shirley Highway Corridor," Comsis Corporation; Silver Spring, Maryland; 1989.

APPENDIX

MODESPLT USERS GUIDE

WHAT IS MODESPLT? It is a stand alone program for a microcomputer operating in a MS/DOS environment that implements a basic procedure for calculating the percentage of person trips (mode split or mode choice or mode share) in an urban area that may be expected to use transit for intraregional travel. As such MODESPLT is the standard model for transit use forecasting intended by TxDOT for application in Transportation Management Areas and other large urban areas in Texas.

The basic program includes "default" parameters and coefficients used by the program, but those parameters and coefficients should be modified to reflect the transit travel propensity and influencing factors for the urban area where it is being applied. Those local parameters and coefficients may be estimated using various kinds of survey data, but they may also be borrowed from models designed for other similar urban areas.

In its present form MODESPLT does not estimate vehicle occupancy or HOV lane usage. These capabilities can added to the model when additional data on those kinds of travel are available. The model does include in its algorithm the instructions for calculating ride sharing and HOV usage so it can be readily adapted to include these modes once the data necessary for calibration are available.

The MODESPLT program is written in Fortran and is designed for full compatibility with the TRANPLAN program battery. MODESPLT uses several standard TRANPLAN subroutines, and data formats for the program are identical to those used by TRANPLAN. Those subroutines have been linked to the executable object module.

As presently configured, MODESPLT operates in a relatively small space and runs quite fast. Trip tables of 197 zones were processed in approximately 3 minutes in a MS/DOS environment.

REQUIREMENTS

MODESPLT is executed by entering the program name. Input and output files are specified as input to the program.

MODESPLT.IN – This is the first of four files of input control information. The user must create a file with this name to tell the program how to proceed. All other file names are specified on this file. The format for the first two parts of this file and default values for each parameter are shown in Figure A1. Additional descriptions are provided below:

1. The first three lines of this file are 80 alphanumeric character records that are the **title** of the run. This can contain virtually any information the user chooses to describe the program run underway.

2. The fourth line is a series of **parameters**, all on one line of the input data set and some of which are not currently used by MODESPLT. All are available for use when the function of the program is broadened to include forecasting car pool size and HOV usage.

   - The **minimum car pool occupancy** dictates who can use the HOV lane, so it is not needed for the current program function and should be coded as 1. This value tells the program that there will be no HOV data input and no processing for HOV usage.

   - The proportion of **intrazonal trips using transit** should be provided and can be calculated by dividing the number of intrazonal transit trips from the transit rider survey by the number of intrazonal person trips from the home interview survey.

   - The proportion of **intrazonal person trips by single-occupant personal vehicles** need not be coded until ridesharing is to be estimated. This could be calculated from the home interview survey.

   - The proportion of **internal/external trips using transit** is unlikely to be necessary and is coded as 0 for the current model operation. This would be necessary only if there were long commute trips into the study area from outside the cordon line. These data would be available from the external survey or the transit rider survey.

   - The proportion of **internal/external trips by single-occupant motor vehicles** need not be coded until ridesharing is to be estimated. This too would be available from the external survey.

   - The **last internal zone** number is self-explanatory.

Figure A1 Data and Format for Parts 1 and 2 of MODESPLT.IN File, Basic Input for the TxDOT Standard Mode Share Model

COLUMNS	DESCRIPTION	VARIABLE NAME	DEFAULT VALUE	FORMAT
1-80	TITLE OF CURRENT PROGRAM RUN (3 of these records are assumed)	UTITLE	blank	A80
1-5	MINIMUM DEFINITION FOR A CAR POOL (0=NO CAR POOL INCENTIVES)	CPDEF	1	I5
6-10	PROPORTION OF INTRAZONAL TRIPS THAT USE TRANSIT	INTTRN	0.081	F5.3
11-15	PROPORTION OF INTRAZONAL TRIPS THAT ARE AUTO DRIVERS	INTADR	0	F5.3
16-20	PROPORTION OF INT/EXT TRIPS THAT USE TRANSIT	IETRN	0	F5.3
21-25	PROPORTION OF INT/EXT TRIPS THAT ARE AUTO DRIVERS	IEADR	0	F5.3
26-30	LAST INTERNAL ZONE	LIZ	197	I5
31-35	HIGHWAY OPERATING COST IN CENTS/MILE	OPCOST	5.8	F5.1
36-40	AVERAGE CAR-OCCUPANCY FOR THE 4+ CAR OCCUPANCY MODE	TCOCC	0	F5.3
41-46	AVERAGE WORK TRIP RATE FOR LOW-INCOME HOUSEHOLDS	TRIPRATE(1)	0.920	F6.3
47-52	AVERAGE WORK TRIP RATE FOR LOW/MEDIUM-INCOME HOUSEHOLDS	TRIPRATE(2)	1.800	F6.3
53-58	AVERAGE WORK TRIP RATE FOR HIGH/MEDIUM-INCOME HOUSEHOLDS	TRIPRATE(3)	2.210	F6.3
59-64	AVERAGE WORK TRIP RATE FOR HIGH-INCOME HOUSEHOLDS	TRIPRATE(4)	2.670	F6.3
65-69	FACTOR TO CONVERT INPUT TRANSIT TIMES TO MINUTES	TRNFAC	0.01	F5.3
70-74	FACTOR TO CONVERT INPUT HIGHWAY TIMES TO MINUTES	HWYTFAC	0.01	F5.3
75-79	FACTOR TO CONVERT INPUT HIGHWAY DISTANCES TO MILES	HWYDFAC	0.01	F5.3

- The **highway operating cost** per mile must be supplied for use in the calculation of the highway disutility that is used in computation for the logit model.

- The **average occupancy of vehicles having four or more occupants** need not be supplied until car pool size is to be computed. This information would be available from the home interview survey or special occupancy surveys.

- The **average work trip rates** for four income levels are used in the program to estimate a breakdown of trips for each income category, primarily for preparing the summary statistics reported on output. Their values can be obtained from the home interview survey.

- The **conversion factors** are needed to establish the location of the decimal points and, thus, the proper values of numbers read from input data sets. These are usually standard conversions consistent among the TRANPLAN programs.

3. The names of the input and output data sets required or optional for the program are provided as one line of information for each data set. It is possible to accommodate up to and including 17 different data sets. Figure A2 shows the format and description of Part 3 of the MODESPLT.IN file; the order of files must be identical to Figure A2 because the program expects to find certain data and formats on the respective logical units.

   - The first field is the logical unit **number of the data set** used by the program.

   - The second field is **the file name** that identifies the data set, including the disk and directory names, where the file is located (if not in the same location as the program).

   - The third field is the **description of the file**. This name is not used by the program except to identify the contents of the files used by the program.

ZONEDATA.IN – Data in this file describe several characteristics of the transportation analysis zones. Each line of data in this file lists these characteristics for one zone. The formats for the data on each record are shown in Figure A3.

Figure A2 Format for Part 3 of MODESPLT.IN File, Basic Input for TxDOT Standard Mode Share Model Input and Output File Definitions and Descriptions

```
UP TO 17 FILE NAME RECORDS MAY BE INCLUDED, ONE RECORD FOR EACH FILE.
THE FILE NAME RECORDS MUST HAVE THE FOLLOWING FORMAT.
   IN COLUMN 2: THE NUMBER OF THE DATA SET
   IN COLUMNS 5 TO 21: THE FILE NAMES, WITH DRIVE AND DIRECTORY IF NECESSARY
   IN COLUMNS 30 TO 59: A DESCRIPTION OF THE DATA SET IN THE NAMED FILE
THE FIRST FILE NAME RECORD IS THE FIFTH RECORD IN THE MODESPLT.IN FILE.

      1= LUN1  IS THE PERSON TRIP TABLE

      2= LUN2  IS THE HIGHWAY SKIM TREES
         TABLE 1 IS ROADWAY NETWORK DISTANCE
         TABLE 2 IS ROADWAY TRAVEL TIME

      3= LUN3  IS THE WALK-ACCESS TRANSIT SKIM TREES
         TABLE 1 IS WALK TIME TO AND FROM TRANSIT
         TABLE 2 IS EXPRESS TRANSIT TIME-TxDOT MODEL
         TABLE 3 IS FIRST WAIT TIME
         TABLE 4 IS TRANSFER TIME
         TABLE 5 IS TRANSIT IN-VEHICLE TIME
         TABLE 6 IS NUMBER OF TRANSFERS

      4= LUN4  IS THE AUTO-ACCESS TRANSIT SKIM TREES
         (not used in the TxDOT model)

      5= LUN5  IS THE LOCAL TRANSIT FARE MATRIX

      6= LUN6  IS THE EXPRESS TRANSIT FARE MATRIX

      7= LUN7  IS THE HOV TIMES AND DISTANCES
         (not used in the TxDOT model)

      8= LUN8  IS THE ZONE DATA (ZONEDATA.IN)

      9= LUN9  IS THE COEFFICIENT FILE (COEFICNT.IN)

     10= LUN10 IS THE OUTPUT TRIP TABLE (TRIPTABL.OUT)
         TABLE 1 IS WALK TO TRANSIT TRIPS
         TABLE 2 IS DRIVE TO TRANSIT TRIPS
         TABLE 3 IS TOTAL TRANSIT TRIPS
         TABLE 4 IS TOTAL HIGHWAY PERSON TRIPS
         TABLE 5 IS AUTO DRIVER TRIPS
         TABLE 6 IS HOV PERSONS AND DRIVERS TRIPS
                    (not used in the TxDOT model)

     11= LUN11 IS THE PRINT OUTPUT (MODLRPRT.OUT)
```

Figure A3 Data and Format for ZONEDATA.IN File, Basic Input for TxDOT Standard Mode Share Model

```
ONE RECORD IS REQUIRED FOR EACH ZONE.
EACH DATA ITEM IS CODED RIGHT JUSTIFIED IN 5 SPACES
 AND READ BY FORTRAN AS A REAL NUMBER (F5.0) EXCEPT
 DISTRICT NUMBER CANNOT EXCEED 99 AND IS READ AS AN INTEGER(I2).

COLUMNS
 1-5         ZONE NUMBER

 6-10        PZONE HIGHWAY TERMINAL TIME

11-15        AZONE HIGHWAY TERMINAL TIME

16-20        DAILY PARKING COST

21-25        PZONE % WALK TO TRANSIT

26-30        AZONE % WALK FROM TRANSIT

31-35        % LOW-INCOME HOUSEHOLDS

36-40        % MED/LOW-INCOME HOUSEHOLDS

41-45        % MED/HIGH-INCOME HOUSEHOLDS

46-50        % HIGH-INCOME HOUSEHOLDS

51-52        DISTRICT NUMBER
```

- The first item is the **number of the zone** whose data are being provided.
- The second and third items are the **terminal times** experienced by motor vehicle users in the production zone and the attraction zone, respectively. These should be estimated with personal knowledge of the amount and location of available parking.
- Item four is the **parking cost** in the attraction zone. This should be based on a survey of the number of available parking spaces and the rate charge for parking in those spaces. The figure entered there should be a weighted average of the spaces available in the attraction zone. For work trips the daily parking rates should be used in the weighting calculation. Short term rates, such as for four hours, should be used for non-work trip purposes other than universities and other schools.
- The next two items are very important. They are the **percentage of transit riders that**

walk to transit in the production zone and **from** transit in the attraction zone, respectively. These are key elements in the program's algorithm to calculate transit disutility. Transit walk times are difficult to estimate because they require judgment regarding the proximity of the population in each zone to the transit line and available transit stops. These times can be estimated by survey or from aerial photographs. A good transit rider survey may provide a good data base for estimating walk times based on reported walk times.

- The next four items are the percentages of **households in the zone that have income** in the four quartiles used for the model. These are used to estimate the number of trips using each mode by persons in each income category. These data can be obtained from the census.
- The final item on the record for each zone is the number of the **summary district** in which each zone is located.

COEFICNT.IN – This file enters the coefficients for variables in the mode choice model. The model uses 33 coefficients if car pooling and HOV usage are being estimated. For the currently operational model, which only estimates transit trips, only 10 coefficients are required. Figure A4 shows the format for each of the coefficient records. The coefficients required for operating the model as currently formulated are for:

- **In-vehicle time for both modes:** the time spent traveling in whatever transportation vehicle is chosen; this same coefficient is used for both highway and transit travel time.
- **Transit out-of-vehicle time:** the times spent waiting for the transit vehicle, transferring between transit vehicles, and walking to and from the transit vehicle stop.
- No coefficient is used in the current model formulation for the **driving time to the transit** stop because the current model is intended for use in cities where very few if any persons drive to a transit stop.
- The same **cost coefficient** is applied to calculate the utilities for trips by both the highway and transit modes.

- Four **coefficients are provided for the four income levels** considered for transit riders in the model.

- Two **nesting coefficients** are available to adjust the **highway and transit** coefficients used in a nested model. The nesting coefficients are not used because the model is currently be operated as a multinomial model.

TRIPTABL.OUT – This is the merged file of five trip tables in typical TRANPLAN format estimated by the model for each zonal interchange. In the present model formulation, only Table 1 of the merged trip tables, the transit trip table for persons walking to transit, has any significance. The other tables will contain information about other modes when the model is broadened.

MODLRPRT.OUT – This is the file with ASCII printed output of reports from the model run. Examples of key summaries produced by the program are shown in Figure A5. Omitted from that figure are the district-to-district trip tables that are produced by the model. This file is not automatically printed by the program but can be read with a text editor or word processing programs and formatted for review.

CONVERSIONS

MODESPLT is run as a stand-alone program outside the program flow of the TxDOT Travel Demand Model (TTDM) system (see Figure 11). It uses roadway description and level of service information and a person trip table produced by the TTDM. It produces a file of transit trips that would be subtracted from the person trips to obtain roadway person trips. The latter file is then divided by vehicle occupancy to obtain roadway vehicle trips which can be processed with capacity restraint, if desired. If capacity restraint is applied, the modified roadway travel times should be used to reestimate trip distribution and mode shares. It would be feasible, though not done to date, to incorporate a vehicle occupancy model into the MODESPLT program to convert roadway person trips to vehicle trips.

Figure A4 FORMATS, DEFAULT VALUES AND COEFFICIENT DEFINITIONS, COEFICNT.IN File – TxDOT STANDARD MODE SHARE MODEL

Order	Name	Default Values	Definition
1	IVTC*	-0.300	IN VEHICLE TIME (all modes)
2	OVTC*	-0.366	TRANSIT OUT OF VEHICLE TIME
3	DRVC	0	DRIVE TO TRANSIT TIME
4	COSTC*	-0.0034	COST (all modes)
5	WRK2C	EXP(0.9589)	2 WORKER HOUSEHOLDS
6	WRK3C	EXP(0.5785)	3 WORKER HOUSEHOLDS
7	TRNINC*	-2.7716	TRANSIT FOR LOW INCOME
8	TRNINC*	-2.9824	TRANSIT FOR LOW-MEDIUM INCOME
9	TRNINC*	-4.0422	TRANSIT FOR HIGH-MEDIUM INCOME
10	TRNINC*	-6.4111	TRANSIT FOR HIGH INCOME
11	TWINC	0	SHARED RIDE 2 FOR LOW INCOME
12	TWINC	0	SHARED RIDE 2 FOR LOW-MEDIUM INCOME
13	TWINC	0	SHARED RIDE 2 FOR HIGH-MEDIUM INCOME
14	TWINC	0	SHARED RIDE 2 FOR HIGH INCOME
15	THINC	0	SHARED RIDE 3 FOR LOW INCOME
16	THINC	0	SHARED RIDE 3 FOR LOW-MEDIUM INCOME
17	THINC	0	SHARED RIDE 3 FOR HIGH-MEDIUM INCOME
18	THINC	0	SHARED RIDE 3 FOR HIGH INCOME
19	FRINC	0	SHARED RIDE 4+ FOR LOW INCOME
20	FRINC	0	SHARED RIDE 4+ FOR LOW-MEDIUM INCOME
21	FRINC	0	SHARED RIDE 4+ FOR HIGH-MEDIUM INCOME
22	FRINC	0	SHARED RIDE 4+ FOR HIGH INCOME
23	NSTHWY*	1	NESTING FOR HIGHWAY
24	NSTSR*	1	NESTING FOR SHARED RIDE
25	NSTTRN*	1	NESTING FOR TRANSIT
26	1	%	2 WORKER HOUSEHOLDS; LOW INCOME
27	25	%	2 WORKER HOUSEHOLDS; LOW-MEDIUM INCOME
28	38	%	2 WORKER HOUSEHOLDS; HIGH-MEDIUM INCOME
29	48	%	2 WORKER HOUSEHOLDS; HIGH INCOME
30	0	%	3 WORKER HOUSEHOLDS; LOW INCOME
31	9	%	3 WORKER HOUSEHOLDS; LOW-MEDIUM INCOME
32	15	%	3 WORKER HOUSEHOLDS; HIGH-MEDIUM INCOME
33	26	%	3 WORKER HOUSEHOLDS; HIGH INCOME

* Coefficients used in the current formulation of the TxDOT Standard Model.

Figure A5 TxDOT Standard Mode Share Model, Formatted Output from File MODLRPRT.OUT

```
SUMMARY OF MODE CHOICE RESULTS
       FOR:        1 PERSON/CAR TRIPS

         INCOME       TRIPS BY INCOME
                         T O T A L
          ---        -----------------
           1              17970.
           2             118311.
           3             118035.
           4             146658.
                     ------------------
         TOTAL           400974.

       SUMMARY OF MODE CHOICE RESULTS
       FOR:       2 PERSONS/CAR TRIPS

         INCOME       TRIPS BY INCOME
                         T O T A L
          ---        -----------------
           1              23714.
           2              28219.
           3              30824.
           4              46758.
                     ------------------
         TOTAL           129516.

       SUMMARY OF MODE CHOICE RESULTS
       FOR:       3 PERSONS/CAR TRIPS

         INCOME       TRIPS BY INCOME
                         T O T A L
          ---        -----------------
           1              22476.
           2              11432.
           3              17721.
           4              18989.
                    ------------------
         TOTAL            70618.

         SUMMARY OF MODE CHOICE RESULTS
         FOR:     4+ PERSONS/CAR   TRIPS

         INCOME       TRIPS BY INCOME
                         T O T A L
          ---        -----------------
           1              16612.
           2              26641.
           3              43035.
           4              50357.
                     ------------------
          TOTAL          136645.
```

Figure A5 (continued)

SUMMARY OF MODE CHOICE RESULTS
FOR: WALK TO TRANSIT TRIPS

INCOME	TRIPS BY ACCESS MODE			
	W A L K	D R I V E	NO TRANSIT	T O T A L
1	15444.	0.	0.	15444.
2	12051.	0.	0.	12051.
3	10228.	0.	0.	10228.
4	7043.	0.	0.	7043.
TOTAL	44767.	0.	0.	44767.

SUMMARY OF MODE CHOICE RESULTS
FOR: DRIVE TO TRANSIT TRIPS

INC	TRIPS BY ACCESS MODE			
	W A L K	D R I V E	NO TRANSIT	T O T A L
1	0.	0.	0.	0.
2	0.	0.	0.	0.
3	0.	0.	0.	0.
4	0.	0.	0.	0.
TOTAL	0.	0.	0.	0.

SUMMARY OF MODE CHOICE RESULTS
FOR: PERSONAL VEHICLE TRIPS

INCOME	TRIPS BY INCOME T O T A L
1	40856.
2	141912.
3	148530.
4	187104.
TOTAL	518402.

SUMMARY OF MODE CHOICE RESULTS
FOR: HWY PERSON TRIPS

INCOME	TRIPS BY INCOME T O T A L
1	80773.
2	184603.
3	209616.
4	262761.
TOTAL	737754.

Figure A5 (continued)

SUMMARY OF MODE CHOICE RESULTS
FOR: TOTAL TRANSIT TRIPS

INCOME	TRIPS BY ACCESS MODE WALK	DRIVE	NO TRANSIT	TOTAL
1	15444.	0.	0.	15444.
2	12051.	0.	0.	12051.
3	10228.	0.	0.	10228.
4	7043.	0.	0.	7043.
TOTAL	44767.	0.	0.	44767.

SUMMARY OF MODE CHOICE RESULTS
FOR: TOTAL TRIPS

INCOME	TRIPS BY INCOME TOTAL
1	96217.
2	196655.
3	219845.
4	269804.
TOTAL	782521.

SUMMARY OF MODE CHOICE RESULTS
PERCENT TRANSIT SHOWN

INCOME	TRIPS BY ACCESS MODE WALK	DRIVE	NO TRANSIT	TOTAL
1	18.576	.000	.000	16.052
2	7.532	.000	.000	6.128
3	5.854	.000	.000	4.653
4	3.488	.000	.000	2.610
TOTAL	7.223	.000	.000	5.721

SUMMARY OF MODE CHOICE RESULTS
CAR OCCUPANCY SHOWN

INCOME	TRIPS BY INCOME TOTAL
1	1.977
2	1.301
3	1.411
4	1.404
TOTAL	1.423

Since MODESPLT uses and produces information in TRANPLAN formats, information received from and produced for the TTDM must be converted to or from those formats. Programs to accomplish those conversions are available and regularly used at both TTI and TxDOT.

It is expected that in most applications the transit network needed by MODESPLT will be coded by the transit operator. In that case it is important that the transit speeds be consistent with motor vehicle speeds coded for the roadway network; however, consideration must be given to the fact that buses operating in mixed traffic will be slower than roadway traffic, because the buses have to stop to pick up passengers.

Further it is expected that the transit operator will prepare the transit trip tables. This will require that purposes and time periods be defined consistently with the person trip tables prepared by TxDOT.

It will also be necessary for the boundaries of the travel analysis zones for the transit and roadway networks and trip tables to be wholly consistent. Those boundaries do not have to be identical; but it must be possible to "map" the smaller zones into the larger zones, so that the resulting zone boundaries are identical.

RUNNING THE PROGRAM

Running the MODESPLT computer program is straightforward. One only has to choose the coefficients to use and change any parameters as necessary. The files must be designated and input prepared in TRANPLAN format. At that point it is simply a matter of calling the program, waiting while it runs, and formatting the printed output from the report file. The data output in the transit trip table are then available for assignment to the transit network or for adjusting the roadway person trips as desired.

The greatest difficulty with this program will be determining the appropriate coefficients for the location being studied. This, of course, can be done with one of the statistical estimating programs or the coefficients can be estimated by adjusting the default coefficients by trial and error until the model satisfactorily reproduces the observed transit trip patterns. In the latter case, estimating the needed coefficients is not unlike calibrating a gravity model for trip distribution.