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16. Abstract

This bibliography is part of an on-going research project between the Texas Transportation Institute (TTI) and the Texas Department of Transportation (TxDOT). The bibliography has attempted to include all significant reports prepared by the Institute in support of urban transportation travel demand modeling and forecasting practice in Texas. An annotation is provided for those reports which still may be of interest to practitioners. Several reports which are now obsolete due to improvements in computer technology are included for completeness and historical interest. In addition several reports prepared by TxDOT which bear directly on travel demand modeling practice are included. The Department reports are not complete and users of this bibliography are requested to provide the Institute with copies of Department reports not presently included so that they may be included in future revisions.

The bibliography is organized into six sections: trip generation, trip distribution, traffic assignment, travel surveys, air quality analysis, and overview. Reports are placed in each section according to the phase of modeling covered by the report. However, since the modeling phases are interdependent, most reports will cover aspects of more than one phase. Reports which clearly cover more than one modeling phase are placed in the overview section.

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Compiled by

Ann M. Horton
Research Associate
Texas Transportation Institute

Hope A. Luedecke
Research Assistant
Texas Transportation Institute

and

George B. Dresser
Research Scientist
Texas Transportation Institute

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The Texas A&M University System
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IMPLEMENTATION STATEMENT

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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 the 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., was the principal investigator for this project.

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SUMMARY

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TRIP GENERATION

GROWTH ALLOCATION BY THE DELPHI PROCESS

Arthur F. Gamble, David F. Pearson, and George B. Dresser, Texas Transportation Institute. Research Study Number 0-1235, Report 1235-12. Sponsored by the Texas Department of Transportation in cooperation with the U. S. Department of Transportation, Federal Highway Administration. February 1993.

As part of a project funded by the Texas Department of Transportation (TxDOT) to examine methods of improving transportation planning techniques, the need to decrease the burden on the planning staff in smaller urban areas (populations less than 200,000) was addressed. In many cases, these smaller areas may not have the financial or personnel resources to determine growth using the traditional models or methods. An existing technique, the Delphi process, was modified to establish a procedure for allocating projected growth at the zone level. A qualitative measure of each zone's growth potential relative to the other zones in the area was established and used to allocate the projections of population and employment. The Delphi process can provide good results in a short time frame which provides the benefit of accelerating the overall planning process. The Delphi process is based on an iterative process. A panel of local experts and involved citizens participates in the process to reach a consensus.

A pilot project was conducted in Longview, Texas, in the summer of 1992 to examine the ability of the Delphi process to allocate future growth. The pilot project employed a three-tiered process in allocating the area's projected population and employment growth (for the year 2015) to 219 traffic analysis zones. Benefits of the Delphi process include reduced costs to the MPO in both time and money; social, political, and legal advantages of basing the allocations on a panel consensus; and the advantages of involving members of local agencies and committees during the allocation process. Support software and a user's manual are currently under development for TxDOT.

TRIPCAL5 PROGRAM DOCUMENTATION MANUAL REVISED EDITION

David F. Pearson, Charles E. Bell, and George B. Dresser, Texas Transportation Institute. Research Study Number 0-1235, Report 1235-6. Sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. February 1992.

This manual is designed to provide technical documentation for the trip generation program TRIPCAL5. It was originally published in February 1992 and is published here in revised form to include documentation on the default models; this documentation is presented as a technical appendix.

In an effort to update the Texas Department of Transportation's transportation planning process, the trip generation program, TRIPCAL5, was developed in 1990. TRIPCAL5 is a multi-functional, flexible program for estimating trip productions and attractions for multiple trip purposes via user-specified models. Trip productions and attractions may be estimated for up to 10 trip purposes and 9,999 zones. The program includes such features as user-specified trip production and attraction models, input of user-developed disaggregate data at the zone level, and/or the disaggregation of the zonal data using default models within the program. The program's flexibility allows the trip generation process to be designed to maximize the use of local data and provides a quantum improvement in the trip generation process.

Included in this report are program options; a brief discussion of the function and purpose of each subroutine; cross-reference of the subroutines and functions; description of each of the variables by labeled common statements; description of the sorts and sort keys; data set formats; how the data flow through the program; discussion of the results of the program tests which were done; and a summary.

The appendix provides technical documentation on the default models which provide flexibility to the user in the application of TRIPCAL5. The use of a disaggregate cross-classification trip generation model is assisted by the provision of these default models in TRIPCAL5. These models will disaggregate households at the zone level and produce reasonable estimates of the percentages of households by household size, household income, and vehicle availability. A default model is also included which estimates the total truck and taxi trip productions within the urban area.

TRIPCAL5 - PROGRAM SPECIFICATIONS INFORMATIONAL REPORT #6

David Pearson and George B. Dresser, Texas Transportation Institute. Research Study Number 2-10-90-1235, Report 1235-2. Cooperative research program of the Texas Transportation Institute and Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. January 1991/August 1991 Revised.

This report documents the research and analysis undertaken to develop a state-of-the-art trip generation model for use by the Texas Department of Transportation (TxDOT). This work was undertaken as a part of an overall effort to improve the transportation planning techniques utilized by TxDOT. Trip generation has been accomplished by TxDOT since the early 1970s using two computer programs, TRIPCAL3 and TRIPCAL4. The methods and

models employed by those programs were considered to be outdated and no longer state of the practice in terms of trip generation. The work documented in this report includes a review of the input data for trip generation, a review of the trip generation rates developed as a result of recent travel surveys, a review of the current trip generation practice in urban areas outside Texas, and a review of the trip generation practice in Texas. Based on those reviews and analyses, specifications and recommendations were developed for a new trip generation program for use by TxDOT as a part of their mainframe travel demand modeling package. The new program is called TRIPCAL5. The implementation of TRIPCAL5 is anticipated to provide a quantum improvement in the trip generation capabilities of TxDOT.

TRIPCAL5 USER'S MANUAL

David Pearson, Charles E. Bell, and George B. Dresser, Texas Transportation Institute. Research Study Number 2-10-90-1235, Report 1235-3. Cooperative research program of the Texas Transportation Institute and the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. November 1990.

In 1989, the Texas Department of Transportation, through the Texas Transportation Institute, began an effort to evaluate and update the practice of transportation planning in the state to equal or exceed current state-of-the-art practice in transportation planning. A new trip generation program, TRIPCAL5, was subsequently developed to replace the trip generation programs TRIPCAL3 and TRIPCAL4 developed in the early 1970s.

TRIPCAL5 is a multi-functional, flexible trip generation program which allows a user to estimate trip productions and attractions for multiple trip purposes using different user-specified models.

This manual provides the information necessary to set up and operate the TRIPCAL5 program. Example setups are included with copies of actual program setups with test data sets and a cross reference of the control/input records necessary for accomplishing specified objectives. One of the features of the program is the ability to use available data for disaggregating households at the zonal level by household size, household income, and/or auto ownership.

SIMPLIFIED TRIP GENERATION TECHNIQUES FOR SKETCH PLANNING, A FEASIBILITY ANALYSIS

J.D. Benson and M.F. Teniente, Texas Transportation Institute. Staff Report TTI Reference Number 0194-2. Sponsored by the State Department of Highways and Public Transportation. August 1977.

This report is one of a series of reports which documents the development and evaluation of the Flexible Abbreviated Study Techniques (FAST). The approach taken in the development of the sketch planning methodology for FAST is essentially a streamlining of the traditional travel demand forecasting procedures and techniques. Two important objectives of any sketch planning methodology are reduced costs and reduced time. The FAST methodology for sketch planning recommends the use of larger zones and less detailed networks.

ACCURACY OF TRAVEL PATTERN ESTIMATES FROM THE HOME INTERVIEW SURVEY

J.D. Benson, D.F. Pearson, and V.G. Stover, Texas Transportation Institute. Research Study Number 2-10-71-167, Report 167-8. Sponsored by the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. March 1974.

This report presents the results of a study of the accuracy of home interview survey data in estimating zonal patterns. The study is primarily based on 100 percent survey data collected by the Texas Highway Department in three apparently homogeneous adjacent zones in San Antonio. The general data analysis demonstrates the general conformance of observed travel characteristics with expected characteristics from urban travel theory. The 100 percent data were used as a data base from which sets of repeated random samples were drawn at various sampling rates. Comparison of the results from the sets of random samples with the actual population data demonstrates the levels of accuracy which may be expected in estimating zonal interactions, interchange volumes, and trip length frequency data. In addition, the entire San Antonio home interview survey was used as the data base to determine the sample size needed to adequately estimate the mean trip length for the urban area.

A PRELIMINARY EVALUATION OF THE TEMPORAL STABILITY OF TRIP GENERATION RATES

D.L. Christiansen and V.G. Stover, Texas Transportation Institute. Research Study Number 2-10-71-167, Report 167-6. Sponsored by the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. April 1973.

This report presents a preliminary study of changes over time in internal person trips per person and internal auto-driver trips per person for urban areas within Texas. Trip generation rates apparently have been increasing as a result of a greater propensity to travel and changes in socioeconomic characteristics. The rate of increase varies among the individual urban areas, being dependent on certain characteristics of the urban area. The historical rates of increase in internal person trips and auto-driver trips per person are identified using macroscopic measures. Although the rate of increase in trip generation rates is expected to decrease in future years, total trip generation is expected to increase

unless the degree of mobility provided by urban street networks is significantly decreased and/or the upward trend in socioeconomic characteristics is arrested or reversed.

AN EVALUATION OF INDUCED TRAFFIC ON NEW HIGHWAY FACILITIES

R.W. Holder and V.G. Stover, Texas Transportation Institute. Research Study Number 2-10-71-167, Report 167-5. Sponsored by the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. March 1972.

This report presents the results of a study of induced traffic on various new highway facilities opened in Texas in recent years. A significant portion of the traffic occurring on some new facilities was identified as induced traffic. Not all locations studied, however, experienced induced traffic. Criteria are developed for evaluating the potential for induced traffic on planned facilities and a procedure is recommended for incorporating an estimate of induced traffic into existing traffic forecasting procedures.

A PARTIAL ANALYSIS OF TRIP GENERATION

J.C. Goodnight, Texas Transportation Institute. Research Study Number 2-8-63-60, Report 60-12. Sponsored by the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. August 1968.

Trip generation by traffic assignment zones was analyzed. Particular items of concern were the relative efficiency of different independent variables used for trip estimates, the effect of stratification of trips by purpose and/or direction, and the comparison of multiple regression with simple rates. Data collected in the 1963-64 Waco Urban Transportation Study were used in the analysis. The analyses were primarily concerned with residential trips. Regression models for nonresidential trip generation productions and attractions, as well as origins and destinations, were developed and analyzed in this study.

AVAILABILITY OF SECONDARY DATA FOR DETERMINING EMPLOYMENT AND SALES BY TRAFFIC ZONES

W.F. McFarland and V.G. Stover, Texas Transportation Institute. Research Number Study 2-8-63-60, Report 60-7. Sponsored by the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. July 1967.

Reliable sources of secondary information on a wide range of land uses, land use activities, and socioeconomic characteristics are needed to facilitate the development of various projections and estimates by traffic zone. To the extent that appropriate secondary data proves satisfactory, the expensive and time-consuming process of primary data collection can be reduced. This report discusses the availability of employment and retail sales data from existing data sources for the state of Texas.

SPECIAL TRAFFIC GENERATOR STUDY 1973-1975

State Department of Highways and Public Transportation, Transportation Planning Division.

The extensive traffic generation study was undertaken from September 1973 through May 1975. Travel data from 318 individual generators, classified by urban area, relative density, and generator type (including residential, commercial, industrial, and others) provided the basis for the results of this analysis.

Although the original intent of the special generator study was to quantify trip rates for various types of generators, it became increasingly evident during the preliminary data analysis that the extreme diversity of generated trips would preclude any simple rate structure. Consequently, several sections of this report are devoted to the examination of the interrelationship of travel variables which affect trip generation.

TRIP DISTRIBUTION

PROGRAM DOCUMENTATION FOR THE TEXAS TRIP DISTRIBUTION MODELS

Charles E. Bell and Jimmie D. Benson, Texas Transportation Institute. Research Study Number 2-10-88-947, Report 947-5. Research performed for the State of Texas. August 1991.

The Texas Trip Distribution Models is a collection of computer programs designed to perform trip distributions featuring the application of either a constrained interactance model or the Atomistic Model. Other programs available in the package provide full support. The purpose of this manual is to provide users with operating instructions for the Texas Trip Distribution Models. Cross references for significant variables and arrays used in the package and formats for all data sets and data cards associated with the package are provided.

This report is part of an on-going research project between the Texas Transportation Institute and the Texas Department of Transportation. It is a major update of the Program Documentation Manual for the Texas Trip Distribution Models and replaces *Operating Manual for the Texas Trip Distribution Package*, Research Study Number 2-10-71-167, Report 167-1; and *Program Documentation Manual for the Texas Trip Distribution Package*, Research Study Number 2-10-71-167, Report 167-2.

IMPLEMENTATION OF A MEZZO-LEVEL HOV CARPOOL MODEL FOR TEXAS

J.D. Benson, J.A. Mullins III, and R.W. Stokes, Texas Transportation Institute. Research Study Number 2-10-87-1103, Report 1103-2F. Cooperative research program of the Texas Transportation Institute and the State Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. November 1989.

This report presents the results of an evaluation and adaptation of three existing high-occupancy vehicle (HOV) lane carpool demand estimation models for possible use in Houston and other large Texas cities. The models evaluated in this study were originally developed for the Washington, D.C. region. These models use trip tables, networks and zone structures that are consistent with the regional travel demand modeling process currently

in use in Texas. By implementing the HOV carpool models in a structure that is consistent with the regional travel demand modeling process, it is possible to estimate the carpool demand for an HOV facility and to evaluate the effects of the following changes in HOV lane configuration and operating strategies: (1) effects of additional and/or alternative access points; (2) effects of extending and HOV lane; and (3) effects of changing the definition of eligible HOV carpools. The models have produced promising results in test applications in Houston.

PROGRAM DOCUMENTATION MANUAL FOR THE TEXAS LARGE NETWORK ASSIGNMENT MODELS

C.E. Bell and Ann Horton, Texas Transportation Institute. Sponsored by the Texas State Department of Highways and Public Transportation. August 1986.

This report is a major revision and consolidation of the Operating Manual for the Texas Large Network Package published in July 1981 and the Program Documentation Manual for the Texas Large Network Package published in April 1972.

The Texas Large Network Assignment Models is a collection of computer programs designed to assign traffic to transportation networks. This manual describes the format specifications and procedures which have been established to operate the package. This manual describes the source code with flowcharts, variable name uses, cross references, and the data set formats.

EFFECTS OF ZONE SIZE IN THE TRIP DISTRIBUTION MODELING PROCESS

J.D. Benson, M.F. Teniente, and C.W. Zipp, Texas Transportation Institute. Staff Report TTI Reference Number 0194-3. Sponsored by the Texas State Department of Highways and Public Transportation. December 1979.

This report is one in a series documenting the development and evaluation of the Flexible Abbreviated Study Techniques (FAST). The effects of zone size and network detail on the determination of the urban travel pattern in the trip distribution modeling process is examined.

The analyses suggest that it would generally be desirable to develop separate estimates of trip length frequencies and intrazonal trips for each significantly different level of zonal detail. Based on the findings of these analyses, it is recommended that a trip distribution modeling technique be developed which considers the activities in a zone to be spatially distributed rather than concentrated at the zonal centroid.

AN IMPROVED MODEL FOR THE ESTIMATION OF TRIP LENGTH FREQUENCY DISTRIBUTIONS

J.D. Benson, M.F. Teniente, V.G. Stover, and W.D. Cunagin, Texas Transportation Institute. Staff Report, TTI Reference Number 0194-5. Sponsored by the State Department of Highways and Public Transportation. August 1979.

This report is in a series documenting the development and evaluation of the Flexible Abbreviated Study Techniques (FAST). The major problem with the original TTI model for the estimation of trip length frequency distributions (the one-parameter gamma model) was its tendency to substantially underestimate the portion of trips a shorter separations for the larger urban areas in Texas and in the right-hand tail estimate of frequency distribution. The previously calibrated one-parameter gamma model tended to decay too rapidly in the tails when estimating the frequency distributions for the larger urban areas.

An improved model, a two-parameter gamma model, was calibrated for application in Texas cities, yielding substantially better estimates of the portion of trips at the shorter separations.

ON THE FEASIBILITY OF APPLYING THE DISAGGREGATE TRIP DISTRIBUTION MODEL FOR SKETCH PLANNING THE HOUSTON-GALVESTON AREA (FINAL REPORT)

J.D. Benson, Texas Transportation Institute. Prepared for the City of Houston. June 1977.

This study evaluated the feasibility of applying the disaggregate trip distribution model to estimate the urban travel pattern for the Houston-Galveston area utilizing an extremely coarse sketch planning zone structure.

A SPATIALLY DISAGGREGATE TRIP DISTRIBUTION MODELING TECHNIQUE, THE DISAGGREGATE TRIP DISTRIBUTION MODEL FOR SKETCH PLANNING AND SUBAREA FOCUSING

J.D. Benson, Texas Transportation Institute. Staff Report TTI Reference Number 0194-4. Sponsored by the State Department of Highways and Public Transportation. June 1977.

This report is one in a series documentng the development and evaluation of the Flexible Abbreviated Study Techniques (FAST). A spatially disaggregate (or atomistic) approach was utilized to ascribe the spatial attributes to a zone. Under this approach, a zone is viewed as being composed of a large number of very small geographical areas. A distribution model for estimating the disaggregate interchange volumes between these small geo-

graphical areas was formulated using the same basic approach employed in the formulation of the Texas Trip Distribution Models.

A Procedure for Estimation of Trip Length Frequency Distributions

D.F. Pearson, V.G. Stover, and J.D. Benson, Texas Transportation Institute. Research Study Number 2-10-74-17, Report 17-1. Cooperative research program of the Texas Transportation Institute and the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. May 1974.

A study was undertaken to determine the feasibility and means of theoretically estimating the trip length frequency distribution for "synthetic" urban transportation studies. The result of this study was the development of a procedure by which the trip length frequency distribution may be theoretically estimated. The procedure requires two inputs: the observed or estimated mean trip length and the maximum separation as defined by the network for the urban area. The procedure was tested and compared with the observed trip length frequency distributions from 18 transportation studies conducted in Texas for home-based and nonwork trip purposes, nonhome-based, and truck-taxi trip purposes. As a whole, the procedure was felt to give results ranging from adequate to excellent.

Program Documentation Manual for the Texas Trip Distribution Package

J.D. Benson, D.F. Pearson, C.E. Bell, and V.G. Stover, Texas Transportation Institute. Research Study Number 2-10-71-167, Report 167-2. Sponsored by the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. March 1974.

This report has been replaced by *Program Documentation Manual for the Texas Trip Distribution Models* by C.E. Bell and C.W. Zipp, published in August 1985.

Operating Manual for the Texas Trip Distribution Package

J.D. Benson, C.E. Bell, G.D. Long, and V.G. Stover, Texas Transportation Institute. Research Study Number 2-10-71-167, Report 167-1. Sponsored by the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. September 1972.

This report has been replaced by *Program Documentation Manual for the Texas Trip Distribution Models* by C.E. Bell and C.W. Zipp, published in August 1985.

AN EVALUATION OF THE GRAVITY MODEL TRIP DISTRIBUTION

G.D. Long, Texas Transportation Institute. Research Study Number 2-8-63-60, Report 60-13. Sponsored by the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. August 1968.

This study was concerned with calibrating and testing the gravity model trip distribution using a small sized urban area, Waco, Texas. An analysis of trip purpose stratification was performed, and it was concluded that no practical differences resulted between a seven purpose, three purpose, and a single purpose model. Upon converting productions and attractions to origins and destinations for purposes of traffic assignment, the single purpose model was seen to differ slightly from the others. The source of this disparity was definitely ascertainable due to entanglements involving the inappropriate conversion of nonhome-based trips. It was suggested that handling the home-based and nonhome-based trips separately as a two purpose model might be satisfactory.

TRAFFIC ASSIGNMENT

TRANPLAN CORRIDOR ANALYSIS PROCEDURES GUIDE

Patricia L. Bass, Tom A. Williams, and George B. Dresser, Texas Transportation Institute. Research Study Number 0-1235, Report 1235-16F. Sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. August 1994.

This report documents a method for developing detailed traffic forecasts and turning movements for use by the Texas Department of Transportation (TxDOT) in roadway project planning and design. The methodology uses a combination of current TxDOT corridor analysis procedures, TRANPLAN travel forecasting applications, and traffic refinement and turning movement estimation procedures from the NCHRP Report 255.

THE STATE-OF-THE-PRACTICE IN FORECASTING TURNING FLOWS

Janis L. Piper, David F. Pearson, and George B. Dresser, Texas Transportation Institute. Research Study Number 2-10-90-1235, Report 1235-11. Sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. February 1993.

The purpose of this project was to develop a better understanding of the process of forecasting turning flows. Review of the literature provided information about the state of the research in the area of turning flow forecasts and provided information about the models available for use in making turning flow forecasts. A telephone survey was performed to obtain information about the state of the practice in forecasting turning flows in the United States. Turning flow proportions were analyzed to show a correlation between turning flow proportion and functional classification, and in doing so, average turning flow proportions were developed.

IMPLEMENTATION OF AN EQUILIBRIUM CAPACITY RESTRAINT MODEL IN THE TEXAS LARGE NETWORK ASSIGNMENT PACKAGE

Charles E. Bell, Jimmie D. Benson, J. Michael Heath, and George B. Dresser, Texas Transportation Institute. Research Study Number 2-10-89-1153, Report 1153-6F. Spon-

sored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. November 1992.

One of the major objectives of Study 2-10-89-1153 has been to improve the accuracy of the assignment models implemented in the Texas Travel Demand Package. Three areas for improvements of the Texas capacity restraint model were identified: improved techniques for estimating iteration weights using an equilibrium approach; user-supplied impedance adjustment functions which can vary by functional class; and an option for computing link impedances which provide for variable weighting of time and distance.

While never implemented in the Texas Package, the equilibrium procedure has become a widely used procedure in operational studies over the past 10 years. The principal difference between the equilibrium model and the capacity restraint procedure implemented in the Texas Package in 1979 is in the iteration weights. In the current Texas procedure, the analyst specifies the weights to be used in combining the iterations. In equilibrium assignments, these iteration weights are computed to minimize the impedance for each trip. An equilibrium capacity restraint assignment procedure, therefore, was implemented in the Texas Package. The procedure was implemented as an option in both the ASSIGN SELF-BALANCING and PEAK CAPACITY RESTRAINT routines. The documentation manuals for these routines was also revised.

DEVELOPMENT, TESTING, AND EVALUATION OF A NODAL RESTRAINT ASSIGNMENT PROCEDURE

Chen Yuan-Wang, J.D. Benson, and G.B. Dresser, Texas Transportation Institute. Research Study Number 2-10-89-1153, Report 1153-5. Cooperative research program of the Texas Transportation and the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. November 1992.

This research proposes a traffic assignment procedure in which capacity restraints are applied to nodes instead of links. The development is based on the concept that the capacity of an urban street system is constrained by nodes instead of links. The nodal restraint assignment procedure was developed by utilizing the concept of the intersection sum of critical lane volumes in the *Highway Capacity Manual 1985*. A nodal impedance adjustment subroutine was incorporated in the assignment process to account for intersection delays where link impedances were held constant and nodal impedances were updated from iteration to iteration. The impedance for each turning movement at a node is determined by the association of all movements encountered at the node.

The proposed procedure was applied to a test network (Preston Road in North Dallas). In the application, various assignment procedures and different impedance adjustment function parameters were used to test the procedure's robustness.

The results from the nodal restraint assignment procedure were compared to the selected "best" of the available conventional capacity restraint assignments based on traffic counts at major intersections on Preston Road. The evaluation was based on micro-level analyses including mean difference, root mean square errors, turning movements as a percentage of approach volumes, and a series of paired t-tests. The analyses show that the nodal restraint assignment generally produced better turning movement replications than the available capacity restraint assignment.

A Comparative Evaluation of the Capacity Restraint Procedures Used in the Dallas-Fort Worth Joint Model and the Texas Package

J.D. Benson and G.B. Dresser, Texas Transportation Institute. Research Study Number 2-10-89-1153, Report 1153-4. Cooperative research program of the Texas Transportation Institute and the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. June 1992.

As part of the investigations to improve the assignment models, a comparative analysis of the Texas Capacity Restraint Procedure and the Joint Model Capacity Restraint Procedure was undertaken. The goal of these analyses was to attempt to objectively compare the two procedures, evaluate how the results of the two procedures differ, and identify (if possible) the primary sources of any differences that may be observed in their ability to replicate observed volumes. It was anticipated that these comparisons would provide the basis for recommending improvements to one or both procedures.

When compared to counted volumes, the results from both assignment techniques were found to produce the same general level of accuracy. Indeed, in view of the major differences in the basic models structures, they both provided surprisingly similar results. The analyses suggest that the results from the preceding modeling steps have more impact on assignment results than the capacity restraint model used for assignment. The comparative analyses did suggest some desirable improvements to be implement in the Texas Capacity Restraint Procedure.

Feasibility of Developing a Statewide Modeling System for Forecasting Intercity Highway Volumes in Texas, Informational Report #7

Jim D. Benson, James A. Mullins III, and George B. Dresser, Texas Transportation Institute. Research study number 2-10-90-1235, Report 1235-4. Cooperative research program of the Texas Transportation Institute and the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. January 1991/October 1991 Revised.

In the urban transportation studies in Texas, computerized network-based models (i.e., the urban travel forecasting models) are used to forecast future traffic volumes on the planned urban freeways and arterials to evaluate the capability of the proposed system to handle the forecast demand. Comparable statewide models (i.e., computerized network-based models) for forecasting intercity highway volumes on the rural segments of the proposed Texas Highway Trunk System are not currently available in Texas. If such a set of models could be implemented for Texas, they would be useful in reviewing and updating the Texas Highway Trunk System Plan every five years. The feasibility of developing and implementing such a statewide modeling system was investigated as a part of the first year program under study 2-10-90-1235. The objectives of this first year effort were:

1. To review and evaluate the current state of the practice for statewide models which focus on forecasting highway volumes on the rural sections of a statewide system such as the Texas Highway Trunk System; and,

2. Based on these investigations, to recommend a set of statewide network-based modeling techniques that could be considered for implementation in Texas.

This report presents the findings and recommendations from this investigation.

IMPACT: HIGHWAY POLLUTANT EMISSION MODEL USER'S GUIDE

G.B. Dresser and C.E. Bell, Texas Transportation Institute. Research Study Number 2-10-88-947, Report 947-3. Cooperative research program of the Texas Transportation Institute and the State Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. May 1991.

Estimation of daily or annual mobile source emissions for metropolitan areas is a continuing requirement for assessing the impact of highway projects or urban area quality, for preparation of State Implementation Plans (SIPS), and for monitoring progress toward air quality standards. This study provides an improved method of analyzing mobile source emissions using disaggregated data available from traffic assignments.

IMPACT is a macroscale computer model that uses a loaded highway network and MOBILE4 emissions factors to compute mobile source emissions. Application is for urban areas that maintain travel demand models utilizing the traditional trip generation, trip distribution, and traffic assignment methodology. IMPACT computes total hydrocarbons or nonmethane hydrocarbons, carbon monoxide, and oxides of nitrogen for each traffic zone or grid in a user-specified grid square superimposed on the study area.

IMPACT is designed to function as part of the Texas Travel Demand Package. The data conversion programs developed as part of this study reformat the output of the Texas Large Network Assignment Models to the Urban Transportation Planning Study format used by IMPACT. IMPACT is appropriate for analyzing an entire urban area or for major traffic cor-

ridor studies. IMPACT is not designed to be used for intersection analysis nor for specific highway projects. IMPACT can be used to assess the combined effect of a number of highway and transit projects completed over a 10- to 20-year planning horizon in conjunction with simultaneous changes in land use and trip making characteristics.

MULTIPATH TRAFFIC ASSIGNMENT: A REVIEW OF THE LITERATURE

C.Y. Wang, V.G. Stover and G.B. Dresser, Texas Transportation Institute. Research Study Number 2-10-89-1153, Report 1153-1. Cooperative research program of the Texas Transportation Institute and the State Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. September 1990.

Most multipath assignment techniques are generated based on either path enumeration or path diversion. Path enumeration models primarily reiterate the assignment procedure with variable link impedance inputs. Burrell's algorithm is a typical path enumeration model in which the link impedances are assumed to be randomly distributed to account for errors in the driver's perception in link travel time. Path diversion models assign trips to alternate paths without repeating the assignment procedure. The most noted path diversion model is Dial's algorithm. Dial's technique originated from logit discrete choice theory in that each "reasonable" path between a particular O-D pair is assigned a portion of the trips according to a route-choice probability.

The literature review indicates that these multiple path algorithms can be incorporated into the capacity-restraint process, either iterative or incremental. Burrell's algorithm can be implemented either in a single-pass procedure or with the capacity-restraint procedure. Paths are enumerated by repeating simulations of link impedances for each origin zone (or a number of origin zones) in a single-pass procedure; paths are enumerated by repeating simulations of link impedances for each assignment stage when combined with the capacity-restraint procedure. In theory, Dial's algorithm can be implemented with the capacity-restraint procedure although his algorithm is a single-pass procedure.

COMPARISON OF TRAFFIC ASSIGNMENT TECHNIQUES

D.M. Chang and G.B. Dresser, Texas Transportation Institute. Research Study Number 2-10-89-1153, Report 1153-3. Cooperative research program of the Texas Transportation Institute and the State Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. August 1990.

This report compares and evaluates the traffic assignment results from five assignment techniques: all-or-nothing, stochastic multipath, iterative, incremental, and equilibrium. The results of the assigned volumes from the five techniques are compared to ground

counts. Various statistical measures are used to evaluate the results. Five different assignments of the existing Tyler, Texas, network were compared to ground counts to determine if there were differences among the results. Measures of the assignment's ability to reproduce traffic counts were divided into two groups: macro-level measurements (screenlines, cutlines, and VMT) which are network-wide analyses and micro-level measures which are link-by-link comparisons.

No significant difference was found among the five assignment techniques when using the macro-level measures. The values for the incremental assignment had the best results compared to ground counts when using micro-level measures.

Some of the statistical measures were affected by the introduction of capacity restraint. Otherwise, it was concluded that the incremental and the equilibrium assignments represented a slight improvement from the all-or-nothing and the stochastic multipath assignments. However, the difference in results was not significant enough when using capacity restraint to warrant the extra cost such as link capacity data and computer run time involved in the capacity-restraint assignments. This implies that much of the precision in the assignment procedure using the different techniques may be sacrificed and still produce acceptable assignment results.

AN IMPROVED TRAFFIC ASSIGNMENT PROCESS FOR PROJECT-LEVEL ANALYSIS

C.S. Chung, V.G. Stover, and G.B. Dresser, Texas Transportation Institute. Research Study Number 2-10-89-1153, Report 1153-2. Cooperative research program of the Texas Transportation Institute and the State Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. August 1990.

This research investigated a restraint assignment procedure which would provide assignment results that are more directly applicable to project-level planning and design. This assignment process was expected to provide more equalized link volume/capacity ratios for the links on the competing roadways within a project area. A prototype assignment model was developed by modifying an existing computer package for urban transportation planning. The assignment results from the prototype assignment model (equalized link V/C ratio assignment procedure) were evaluated to determine whether and how well the link V/C ratios of the links on the competing routes were actually equalized. In addition the accuracy of the assigned link volumes were evaluated by comparing them to the counted volumes. Also, the assigned turning volumes were compared with the results from the incremental restraint assignment technique. Three networks were used for the evaluation; these were the existing network used in the Tyler urban transportation study, a network in which the link capacities were reduced to make the network "congested," and a congested network in which the project area was coded in greater detail.

The research found that for the congested networks, the V/C ratio assignment procedure tended to equalize the v/c ratios for the links on the competing routes within the project area. It produced assigned link volumes which more closely agreed with counted volumes than those from the incremental assignment. Also, the turning volumes produced by this assignment were judged to be more reliable.

How to Read the Output Tables of the Texas Large Network Assignment Models

D.M. Chang, J. Gattis, and G.B. Dresser, Texas Transportation Institute. Research Study Number 2-10-88-947, Report 947-2. Cooperative research program of the Texas Transportation Institute and the State Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. May 1990.

The Texas Travel Demand Package is a series of computer programs to generate, distribute, and assign roadway trips. The Texas Large Network Assignment Models is a collection of computer programs designed to assign traffic to transportation networks; it is one part of the Texas Travel Demand Package. Several special features are available in the Texas Large Network Assignment Models in addition to the usual programs regarding assignment of traffic to minimum time paths, such as self-balancing assignment, capacity-restraint assignment, incremental assignment, corridor intercepts, travel routes, selected links, and subarea windowing and subarea focusing assignment techniques.

Since the Texas Large Network Assignment Models can be used to accomplish various jobs, the Models output a number of different tables. This writeup describes these various tables and tells how to read them. This report begins with a general discussion of the objectives of evaluating a traffic assignment output. Various steps of evaluation assignment output are discussed. The report then lists the designators and names of the output tables. Finally, the report contains a detailed discussion of the various tables including the following sequence: purpose, how to read, comments, how to use, and sample output tables.

Traffic Forecasting for Project Development

V.G. Stover, D.M. Chang, C.S. Chung and G.B. Dresser, Texas Transportation Institute. Research Study Number 2-10-87-1112, Report 1112-1F. Cooperative research program of the Texas Transportation Institute and State Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. November 1989.

The traditional modeling process was developed in response to the need to evaluate future transportation needs in large, rapidly growing urban areas. The process is an excel-

lent tool for evaluation of land-use/transportation alternatives. However, it is generally recognized that such a system level must be refined for project-level applications. A case study showed that the manual procedure followed by the Texas Corridor Analysis Group produced results which were different from the traffic assignment results using the TRANPLAN microcomputer package. A new alternative procedure for performing corridor analysis is proposed. This procedure is illustrated through a case study.

A capacity restraint procedure which equalizes the V/C ratio of groups of links constituting competing routes was developed and tested. The prototype model demonstrated that the V/C ratios of the links in each group converge toward the average V/C for that group. Counted volumes for turning movements were not available. Therefore, the assigned turning movements utilizing the equalized link V/C ratio method were compared to the results using the incremental capacity restraint procedure. The equalized link V/C procedure was judged to produce turning movements which are more realistic than the present capacity restraint method.

SUBAREA ANALYSIS USING TRANPLAN/NEDS

D.M. Chang, and G.B. Dresser, Texas Transportation Institute. Research Study Number 2-10-87-1110, Report 1110-4F. Cooperative research program of the Texas Transportation Institute and the State Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. November 1988.

The primary objective of this study is to develop and incorporate into the Texas Travel Demand Package procedures for downloading a portion of the output from the Package to the selected microcomputer transportation planning package to perform subarea analysis. In order to get compatible results between TRANPLAN and the Texas Trip Distribution Models, it is recommended that the final (or fifth) relative values from MODEL or ATOM be used for the Friction-Factors in the TRANPLAN trip distribution. The modified R-VALUE from ATOM is recommended for the "assumed average" intrazonal impedance of the TRANPLAN separation matrix. The results of the comparison indicate that there are slight differences in the trip tables between TRANPLAN and ATOM, but the difference are of no practical significance. It is recommended that the user-specified V/C time adjustment curve data be used in the TRANPLAN assignment. The recommended user curve data are essentially from the final formulation of the impedance adjustment function in the Texas Package. General descriptions of subarea analysis and procedure are discussed in this report. The conversion programs between the mainframe and the microcomputer were developed and tested. The program documentation is attached in Appendix C. Menu-driven batch files were developed to execute the conversion programs. The batch files are user friendly and make full use of the interactive capability of the microcomputer.

COMPARISON OF THE RESULTS FROM TRANPLAN WITH THE TEXAS PACKAGE

D.M. Chang, V.G. Stover, and G.B. Dresser, Texas Transportation Institute. Research Study Number 2-10-87-1110, Report 1110-2. Cooperative research program of the Texas Transportation Institute and the State Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. October 1988.

This report represents the comparison of the results from TRANPLAN with the Texas Travel Demand Package (Texas Package) incorporated in a research project entitled "Subarea Analysis Using Microcomputers." One of the study objectives is to develop and incorporate into the Texas Package procedures for downloading a portion of the output from the Texas Package to the selected microcomputer transportation planning package to perform subarea analysis. TRANPLAN was tested and recommended for interface with the Texas Package. A two-phase test procedure was utilized: Phase I — assignment comparisons using the same trip table and Phase II — trip table comparisons. The 1985 network in Bryan-College Station, Texas, was selected as the data base for this test. The results from the TRANPLAN assignments using three different assignment techniques were compared to the Texas Large Network Assignment Models results. The analysis included selected link, screenline, cutline, and major travel route comparisons. Phase II investigated alternative trip distribution techniques (i.e., TRANPLAN, Texas Model, and Atomistic distributions) for the modeling of the trip table. The results of three trip tables were then compared on a cell-by-cell basis. It was found that there were no differences using All-or-Nothing, and that there were no significant differences between the TRANPLAN Incremental assignment and the new capacity restraint assignment of the Texas Large Network Assignment Models. There are slight differences of trip tables between TRANPLAN and MODEL, but the differences are not practically significant.

DETAILED EVALUATION OF THE TRANPLAN PACKAGE OF MICROCOMPUTER PROGRAMS

D.M. Chang, V.G. Stover, and G.B. Dresser, Texas Transportation Institute. Research Study Number 2-10-87-1110, Report 1110-1. Cooperative research program of the Texas Transportation Institute and the State Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. October 1988.

This report represents the detailed evaluation of the TRANPLAN package including sample control files and outputs incorporated in a research project entitled "Subarea Analysis Using Microcomputers." One of the study objectives is to develop and incorporate procedures into the Texas Travel Demand Package for downloading a portion of the output from the Texas Package to the selected microcomputer transportation planning package to perform subarea analysis. The TRANPLAN package was tested and recommended for interface with the Texas Package.

TRANPLAN is a comprehensive, fully-integrated, user-oriented transportation modeling software with highway and transit programs. Unlike other software, TRANPLAN uses English-like syntax and uniform specification in all programs. TRANPLAN is distributed on 12 (13 if plotting) diskettes and requires about 3.5 MB of storage if all programs are transferred to a hard disk. The entire set of programs is separated into 42 modules referred to as "FUNCTIONS," each of which has specific capabilities. TRANPLAN documentation is available in hard copy. The package also includes substantial plotting capability. Recently, TRANPLAN has been interfaced with on-line, interactive graphics software for Network Editing and Display (NEDS). Detailed evaluation of TRANPLAN plotting capabilities and NEDS are included in this report.

DEVELOPMENT OF A PEAK PERIOD TRAFFIC ASSIGNMENT CAPABILITY

J.D. Benson, C.E. Bell and V.G. Stover, Texas Transportation Institute. Research Study Number 2-10-87-454, Report 454-1F. Cooperative research program of the Texas Transportation Institute and the State Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. August 1988.

The basic objective of this study was to develop and incorporate into the Texas Travel Demand a peak hour or peak period travel demand modeling capability. Peak hour and peak period travel demand modeling techniques vary considerably in their level of sophistication. These techniques can generally be categorized into three basic approaches: factoring of 24-hour trip tables; factoring of 24-hour trip ends; and direct generation.

Two sets of data analyses were performed: (1) analyses of traffic count data from 254 locations in Houston, and (2) analyses of peak period data from the recent Houston travel survey. Based on the results of these analyses and some basic conceptual concerns, the use of three-hour peak periods instead of a single peak hour for travel demand modeling applications is strongly encouraged.

Perhaps the most important product of this study is the software. Three new routines were developed, tested and implemented in the Texas Travel Demand Package to provide for peak period modeling applications.

DEVELOPMENT AND IMPLEMENTATION OF A NEW IMPEDANCE ADJUSTMENT FUNCTION FOR CAPACITY RESTRAINT TRAFFIC ASSIGNMENT

J.D. Benson and W.D. Cunagin, Texas Transportation Institute. Staff Report. Sponsored by the Texas State Department of Highways and Public Transportation. February 1980.

Capacity Restraint Traffic Assignment is a discretionary tool available to the analyst. Use of this tool is indicated when the assigned volumes on links or routes comprising a given corridor do not appear reasonable compared to counted volumes (during model validation) or capacities (for the forecast year). In this paper, a new impedance adjustment function for capacity restraint is introduced. The most significant difference between the new impedance adjustment function and the old Texas Procedure is that with the new function, the link impedances are adjusted after each iteration for every link having a specified capacity whether or not the adjusted link volume is over or under capacity. The old procedure adjusted link impedances only for those links where the assigned volume exceeds capacity.

Development and Evaluation of the FAST Subarea Focusing Procedure

J.D. Benson, M.F. Teniente, and C.W. Zipp, Texas Transportation Institute. Staff Report TTI Reference Number 0194-1. Sponsored by the Texas State Department of Highways and Public Transportation. December 1979.

This report is one of a series documenting the development and evaluation of the Flexible Abbreviated Study Techniques (FAST). FAST provides cost-effective analytical techniques for sketch planning and subarea focusing.

The trip distribution evaluations demonstrate the feasibility of using the Atomistic Model in subarea focusing applications. The two principal advantages realized in using the Atomistic Model are: (1) it allows the use of the same desired trip length frequency distribution when modeling at varying levels of zonal detail, and (2) it does not require the analyst to estimate the desired intrazonal trips and to subsequently control them in the trip distribution modeling process. By considering the activities within a zone to be spatially distributed, the Atomistic Model can be expected to yield travel pattern estimates more consistent with basic travel theory than the Texas Model when dealing with very large zones such as the sectors used in subarea focusing applications.

Consequences of Small Sample O-D Collection in the Transportation Planning Process, Final Report

R.E. Foster, V.G. Stover, and J.D. Benson, Texas Transportation Institute. Report Number FHWA-RD-76-43. Prepared for Federal Highway Administration, Office of Research and Development and Office of Highway Planning, Washington, D.C. 20590. January 1976.

This report presents the results of a study of the adequacy of small samples of O-D survey data as the basis for urban transportation planning models. The study was based primarily on 1-in-20 survey data collected in the 1959 San Antonio-Bexar County Urban Transportation Study (SABCUTS). The general data analysis demonstrated the ability of

small samples of O-D as input sources for urban transportation planning models to produce travel estimates for individual zones and for the study areas which are in close agreement with and comparable to travel estimates based on the full survey data.

A Sensitivity Evaluation of Traffic Assignment

J. Buechler, V.G. Stover, and J.D. Benson, Texas Transportation Institute. Research Study Number 2-10-74-17, Report 17-2. Cooperative research program of the Texas Transportation Institute and the State Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. August 1975.

The purpose of this study was to investigate the sensitivity of traffic assignment of input from the preceding modeling phases (i.e., the trip generation and trip distribution phases). The analyses focused not only on sensitivity of assignment results to inaccuracies from the modeling phases but the sensitivity of various commonly used measures of assignment accuracy in discerning such inaccuracies.

Based on the results of these analyses, a "short-cut" (sketch planning) approach is proposed, which would be expected to produce assignment results of sufficient accuracy for preliminary system evaluation and comparison with other alternatives similarly modeled.

Program Documentation Manual for the Texas Small Network Package

J.D. Benson, C.E. Bell, and V.G. Stover, Texas Transportation Institute. Research Study Number 2-10-71-167, Reports 167-3. Cooperative research program of the Texas Transportation Institute and the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. April 1972.

The Texas Small Network Package is no longer maintained by the Texas Department of Transportation.

Program Documentation Manual for the Texas Large Network Package

J.D. Benson, C.E. Bell, and V.G. Stover, Texas Transportation Institute. Research Study Number 2-10-71-167, Report 167-4. Sponsored by the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. April 1972.

This report is superseded by *Program Documentation Manual for the Texas Large Network Assignment Models* by C.E. Bell and Ann Horton, Texas Transportation Institute, sponsored by the Texas State Department of Highways and Public Transportation, August 1986.

OPERATING MANUAL FOR THE TEXAS SMALL NETWORK PACKAGE

G.D. Long, C.E. Bell, and V.G. Stover, Texas Transportation Institute. Research Study Number 2-10-68-119, Report 119-1. Sponsored by the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. October 1971.

The Texas Small Network is no longer maintained by the Texas Department of Transportation.

OPERATING MANUAL FOR THE TEXAS LARGE NETWORK PACKAGE

C.E. Bell, Texas Transportation Institute. Research Study Number 2-10-68-119, Report 119-2. Sponsored by the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. February 1970 (Revised July 1971).

The Texas Large Network Package is a collection of computer programs designed to assign traffic to large transportation networks. The package has been prepared for use with an IBM 360 computer system.

Several special features are available in the Texas Large Network Package in addition to the usual programs regarding the assignment of traffic to minimum time paths. A self-balancing assignment program is included which can improve the agreement of assigned volumes with counted volumes. The self-balancing assignment program also can be used to induce a compliance of the assigned volumes with capacity limitations. Corridor intercepts may be coded to obtain corridor analysis summaries, travel routes may be coded to obtain volume profile comparisons and/or plots, and selected links may be indicated for a special analysis of all traversing movements. Under normal operation, each assignment is preserved and compared with previous assignments.

THE EFFECT OF TURN PENALTIES ON MINIMUM PATHS IN CODED STREET NETWORKS

J.T. Brudeseth and D.L. Woods, Texas Transportation Institute. Research Study Number 2-8-63-60, Report 60-10. Sponsored by the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. April 1968.

A total of 33 sets of trees with and without a turn penalty were plotted and analyzed. Minimum path trees without a turn penalty (zero turn penalty) did not differ significantly from those when a 0.2 minute turn penalty was used. Illogical routings resulted just as often or more often with the 0.20 minute turn penalty as with the zero turn penalty.

No significant stair-stepping occurred in any of the paths — even with the well-defined grid system of the detailed network which is a block-by-block representation of the Waco, Texas, street network. It is believed that this is due to the level-of-speed concept used in defining the link speed parameter. The coding of a higher level-of-service speed for the more important, higher volume links appears to prevent stair-step paths.

THE EFFECT OF NETWORK DETAIL ON TRAFFIC ASSIGNMENT RESULTS

G.D. Long and V.G. Stover, Texas Transportation Institute. Research Study Number 2-8-63-60, Report 60-11. Sponsored by the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. August 1967.

This research is concerned with ascertaining the value and effect of increased coded network detail on traffic assignment results. The Waco, Texas, urban area was selected for use in the study, and three street system representations with greatly different degrees of detail were coded. Comparisons of traffic counts with the corresponding assigned volumes that resulted from each of three networks were analyzed with respect to screenline crossings, arterial streets, selected links, etc. Improved assignment results were NOT observed to accompany increased network detail. The networks with greater detail, however, presented extensive problems with respect to coding, data handling, adjustment, and analysis.

THE EFFECT OF ZONE SIZE ON TRAFFIC ASSIGNMENT

D.L. Woods and V.G. Stover, Texas Transportation Institute. Research Study Number 2-8-63-60, Report Number 60-8. Sponsored by the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. August 1967.

The purpose of this study was to evaluate the effect of zone size on assigned link volumes. This was accomplished by comparing the volumes assigned to a common basic network using three different zone-size configurations. Assigned link volumes using medium and large zones were compared with those using small zones. It is concluded that zones as large as a half square mile can be used without serious or practical effect on the traffic assignment results. This conclusion is considered valid for medium size urban areas and for low density areas (such as single family residential) in any urban area.

TEXAS TRAFFIC ASSIGNMENT PRACTICE

V.G. Stover and J.T. Brudeseth, Texas Transportation Institute. Research Study Number 2-8-63-60, Report 60-9. Sponsored by the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. July 1967 (Revised October 1967).

The decentralized organization of the Texas Highway Department with its several districts and urban areas requires that a large number of engineers in various locations be familiar with the data produced by the traffic assignment process. This manual is intended to provide the Highway Design Engineer with a guide for the use of computer traffic assignment data as developed in Texas in the geometric design of proposed highway facilities.

THE FOLLOWING REPORTS ARE NO LONGER RELEVANT DUE TO IMPROVEMENTS IN COMPUTER TECHNOLOGY:

TEXAS A&M TRAFFIC ASSIGNMENT LINK DATA EDITOR FOR IBM 1401 DATA PROCESSING SYSTEM

G.N. Williams, Texas Transportation Institute. Research Study Number 2-8-63-60, Report 60-1. November 1963.

TEXAS A&M TRAFFIC ASSIGNMENT EDIT PRINT TRIP VOLUMES FOR IBM 1401 DATA PROCESSING SYSTEMS

W.F. Pry, Texas Transportation Institute. Research Study Number 2-8-63-60, Report 60-2. November 1963.

TRAFFIC ASSIGNMENT PLOT SYSTEMS FOR IBM 1401 AND IBM 709-90-94 DATA PROCESSING SYSTEMS

W.F. Pry, Texas Transportation Institute. Research Study Number 2-8-63-60, Report 60-3. September 1964.

UTILIZATION OF COMPUTER PLOTTING IN TRAFFIC ASSIGNMENT ANALYSIS

W.F. Pry and C. Pinnell, Texas Transportation Institute. Research Study Number 2-8-63-60, Report 60-4. November 1964.

OPERATING SYSTEM MANUAL FOR REVISED TEXAS TRAFFIC ASSIGNMENT SYSTEM

C.W. Blumentritt, Texas Transportation Institute. Research Study Number 2-8-63-60, Report 60-5. March 1965.

USER'S MANUAL FOR THE TEXAS LARGE SYSTEMS TRAFFIC ASSIGNMENT PROGRAMS

V.G. Stover and C.W. Blumentritt, Texas Transportation Institute. Research Study Number 2-8-63-60, Report 60-6. November 1966.

TRAVEL SURVEYS

URBAN TRAVEL DEMAND MODELING DATA

David F. Pearson and George B. Dresser, Texas Transportation Institute. Research Study Number 0-1235, Report 1235-7. Sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. November 1994.

This report documents an overview of the travel surveys done in Texas during 1984 through 1991 relative to the data requirements for development of travel demand models. A comprehensive review and evaluation of the methods and techniques for developing regional and zonal estimates of urban data for use in travel demand models is presented. This review and evaluation included both theoretical considerations and the methods and techniques in use in urban areas within and outside of Texas. No single method or technique was found to be superior. The techniques in use vary considerably between urban areas depending on their size and complexity. Recommended methods are made for the development of regional and zonal level estimates of population, households, employment, household income, and vehicle availability. These methods may not be applicable in all urban areas but may serve as useful guides for the development of local techniques in estimating the input data for travel demand modeling.

EVALUATION OF URBAN TRAVEL SURVEY METHODOLOGIES

David F. Pearson and George B. Dresser, Texas Transportation Institute. Research Study Number 0-1235, Report 1235-10. Sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. October 1994.

This report documents the evaluation of the methodologies used in the travel surveys done in five urban areas in Texas in 1990 and 1991. Based on those evaluations, specific recommendations are made in the areas of sample size estimation, survey methodologies, data specifications, survey instruments, etc. Evaluated were household surveys, workplace surveys, special generator surveys, external station surveys, and truck surveys. Several travel data gaps are also identified where current survey efforts are not sufficient in terms of providing data for their estimation or modeling.

AN EVALUATION OF THE PILOT WORKPLACE SURVEYS IN BEAUMONT-PORT ARTHUR

David F. Pearson and Vergil G. Stover, Texas Transportation Institute. Research Study Number 0-1099, Report 1099-2. Sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. September 1993.

A pilot survey of workplaces was conducted as part of the comprehensive travel survey in the Beaumont-Port Arthur, Texas, area. The methodology used in the pilot survey was significantly different than that used in the 1990-91 workplace surveys in Texas. The methodology used in the 1990-91 surveys was flawed in its theoretical basis. This paper analyzes the pilot surveys to determine the impact of the new methodology recommended for workplace surveys. The findings of this analysis indicate that the new methodology produces lower attraction rates for non-freestanding workplaces as compared to freestanding workplaces. Based on these findings, the new methodology produces more representative results; and a recommendation is made for the Texas Department of Transportation to continue conducting workplace surveys using the methodology described in the technical note, Workplace Survey Design.

URBAN TRAVEL IN TEXAS

David F. Pearson, Texas Transportation Institute. Research Study Number 0-1099, Report 1099-1. Sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. April 1993.

In 1990, the Texas Department of Transportation (TxDOT) approved funding for travel surveys in five urban areas in Texas: San Antonio, Amarillo, Brownsville, Tyler, and Sherman-Denison. TxDOT began a major effort to identify current travel characteristics and the changes that have occurred over time in Texas. These surveys were designed to update models used to estimate travel demands and the impact of those demands on air quality and energy consumption. The models in use prior to initiating the surveys, with two exceptions, were based on information gathered in origin-destination surveys conducted in the 1960s and early 1970s.

Prior to 1990, travel surveys had been done in the Dallas-Fort Worth area, the Houston-Galveston area, and the Texarkana area. While there were some similarities between these surveys, each was significantly different in certain areas considered critical for comparison purposes. The surveys funded by TxDOT in 1990 used the same survey instruments and, with minor exceptions, were consistent in their implementation.

The information obtained in these surveys is critical for monitoring changes in travel characteristics and for projecting travel demands in the future. They provide an insight to the changes that have been and are occurring. The information will improve TxDOT's ability to anticipate and plan future transportation improvements through a broader under-

standing of the changes in travel characteristics and through the development of better tools for predicting travel.

This report presents an overview of the major surveys done in 1990 and, where possible, the surveys done in the Dallas-Fort Worth area, the Houston-Galveston area, and the Texarkana area. Comparisons were not possible in all aspects of the surveys and, in certain areas of this report, data will be presented for less than eight urban areas. This report also presents a comparison between the travel characteristics observed in the origin-destination surveys conducted in the 1960s and 1970s and the characteristics observed in the most recent surveys.

ACCURACY OF TRIP END ESTIMATES FROM THE HOME INTERVIEW SURVEY

J.D. Benson, D.F. Pearson, and V.G. Stover, Texas Transportation Institute. Research Study Number 2-10-71-167, Report 167-7. Cooperative research program of the Texas Transportation Institute and the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. March 1974.

This report presents the results of a study of the accuracy of home interview survey data in estimating zonal trip ends. The study is based on 100 percent survey data collected by the Texas Highway Department in three apparently homogeneous, adjacent zones in San Antonio. The general data analysis confirmed the homogeneity of the travel characteristics of the zones. A large number of repeated random samples were drawn at various sampling rates and the results used to verify the basic assumptions and general applicability of a set of theoretical relationships between sample size and the expected error of estimation. The analysis of disaggregate zonal data was directed toward the accuracy of home interview data in estimating the population mean (i.e., the mean trips per dwelling unit) and the population variance (i.e., the variance between dwelling units in trip productivity).

AIR QUALITY ANALYSIS

TEXAS MOBILE SOURCE EMISSIONS SOFTWARE VERSION 2.0 USER'S GUIDE

Charles E. Bell, Jimmie D. Benson, and George B. Dresser, Texas Transportation Institute. Research Study Number 0-1279, Report 1279-9. Sponsored by the Texas Department of Transportation in cooperation with U.S. Department of Transportation, Federal Highway Administration. February 1995.

This research report, which updates Research Report 1279-2, is a user's guide with operating instructions for each program. The mainframe programs were developed to estimate mobile source emissions and vehicle miles traveled (VMT). The PREPIN program allows the analyst to factor a 24-hour assignment to estimate the VMT and speeds for a subject time period. The POLFAC5A program is used to apply MOBILE5a to obtain emission factors without HC species. The POLFAC5B program is used to apply MOBILE5a to obtain emission factors including HC species. The COADJ program is used to add two sets of emission factors and subtract a third set of emission factors from POLFAC5A to produce a combined set of emission factors. RATEADJ, a special utility program, combines emission factors from three applications of the POLFAC5B program to produce a new set of emission factors. IMPSUMA facilitates the computation of emissions by using the emission factors from POLFAC5B and RATEADJ. SUMALLA sums the emission results from two or more time periods plus diurnals. IMPSUMA and SUMALLA have the additional capability of producing gridded emission estimates by vehicle type. A microcomputer program, JCFBATCH, was added to document POLFAC5B, IMPSUMA, SUMALLA, RATEADJ, and VMTSUM runs on the microcomputer and to make these runs easier.

DEVELOPMENT OF EMISSION ESTIMATES FOR THE CONFORMITY ANALYSIS OF THE JOHRTS FY-94 TIP AND MTP

Charles E. Bell, Jimmie D. Benson, and George B. Dresser, Texas Transportation Institute. Research Study Number 0-1375, Report 1375-6. Sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. January 1995.

This report documents the mobile source emission estimation methodology used for the conformity analysis of the Transportation Improvement Program (TIP) and the metropolitan

transportation plan (MTP) for Jefferson and Orange Counties and a portion of Hardin County. Included in the report is a brief overview of the emission estimation methodology and the 24-hour traffic assignments used in the analyses; the methods used to estimate the seasonally adjusted time-of-day vehicle miles of travel and associated operating speeds; the estimation of the emission rates using the EPA's MOBILE5a program; and brief outlines of the method used to develop the emission estimates using the MOBILE5a emission rates and comparisons of the emission estimates for the Build and No-Build Options. An appendix presents the emission rates developed for conformity analysis.

EL PASO TIP AND MTP 1995 - 2015 CONFORMITY ANALYSIS

Jimmie D. Benson, George B. Dresser, and Charles E. Bell, Texas Transportation Institute. Research Study Number 0-1375, Report 1375-5. Sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. December 1994.

This report documents the mobile source emissions estimation methodology used for the conformity analysis of the Transportation Improvement Program (TIP) and the metropolitan transportation plan (MTP) for El Paso. Included in the report is a brief overview of the emission estimation methodology and the 24-hour traffic assignments used in the analyses; the methods used to estimate the seasonally adjusted time-of-day vehicle miles of travel and associated operating speeds; the estimation of the emission rates using the EPA's MOBILE5a program; and brief outlines of the method used to develop the emission estimates using the MOBILE5a emission rates and comparisons of the emission estimates for the Build and No-Build Options. An appendix presents the emission rates developed for conformity analysis.

TCM ANALYST 1.0 AND USER'S GUIDE

Jason A. Crawford, K.S. Rao, and Raymond A. Krammes, Texas Transportation Institute. Research Study Number 0-1279, Report 1279-7. Research performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration. November 1994.

Since the passage of the 1990 Clean Air Act amendments (CAAA), transportation planning has increased its focus on the air quality impacts of transportation improvement projects. Transportation control measures (TCMs) are possible tools for improving regional air quality as defined in the CAAA. TCMs are a collection of actions previously grouped into two categories: transportation system management (TSM) and transportation demand management (TDM). The TCM Analyst computer package was prepared to provide a tool for evaluating the effectiveness of TCMs on a regionwide basis and is intended to be used by transportation engineers and planners.

Traditionally, three broad categories of methodologies have been employed for TCM analysis: comparison with other areas, computer-based modeling, and sketch planning tools. Comparison with other areas involves a simple application of the observed changes in travel activity due to TCM implementation in another area to a local scenario. Computer-based modeling involves using changes in travel activity due to TCM implementation in another area to a local scenario. Computer-based modeling involves using complex simulation tools traditionally employed in transportation planning and traffic engineering. Sketch planning tools involve simple manual or computerized methods and fall between the two previously described methods in complexity and formality.

The TCM Analyst is a sketch planning tool that combines elements of the methodologies developed by Systems Applications International (SAI) for the U.S. Environmental Protection Agency (EPA) and the San Diego Association of Governments' (SANDAG) TCM Tools program into one spreadsheet-based evaluation tool. The software uses the Microsoft Excel spreadsheet environment as a platform for TCM analysis.

The TCM Analyst can be used to estimate the travel and emission effects of selected TCMs and can also evaluate their cost-effectiveness. Eleven TCMs are included for evaluation in the TCM Analyst: (1) Telecommuting, (2) flextime, (3) compressed work week, (4) ridesharing, (5) transit fare decrease, (6) transit service increase, (7) transit plazas, (8) parking management, (9) HOV lanes, (10) traffic signalization, and (11) intersection improvements. Emission changes are evaluated for both the carbon monoxide and ozone emission seasons. Additionally, three analysis tools are included to help determine the effects that specific inputs have on the estimated benefits of TCM.

STATE-OF-THE-PRACTICE REPORT ON MOBILE SOURCE EMISSIONS MODELS

Amy R. Stephenson and George B. Dresser, Texas Transportation Institute. Research Study Number 0-1279, Report 1279-3. Sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. August 1994.

Air quality nonattainment areas must use computer models to estimate the mobile source portion of emission inventories for the State Implementation Plan. Mobile source emissions estimates are produced for the emission inventory by multiplying an emission factor by a measured vehicle activity (such as vehicle miles of travel). The Environmental Protection Agency requires the use of their model, MOBILE, to produce emission factors for all states except California. California uses its own emission factor model, EMFAC. Travel demand models, used for transportation planning, produce the needed vehicle activity data. Emissions modeling systems act as interfaces between the emission factor models and travel demand models, pulling data from both models to calculate mobile source emissions estimates.

This report describes emissions modeling systems that are currently being used or have recently been used for air quality analysis aspects of transportation planning. Both MOBILE and EMFAC are described, and concerns about the accuracy of their emission factors are reported. Each emissions modeling system is described, including major inputs and outputs, and which emission factor model and travel demand model the emissions model will interface with. The authors evaluated each emissions modeling system for possible use in Texas and found that none of them offer significant advantages in features, accuracy, or ease of use over the emissions modeling system currently being used in Texas.

Development of Emission Estimates for the Conformity Analysis of the El Paso FY-94 TIP

Jimmie D. Benson, George B. Dresser, and Charles E. Bell, Texas Transportation Institute. Research Study Number 0-1375, Report 1375-2. Sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. July 1994.

This report documents the mobile source emissions estimation methodology used for the conformity analysis of the Transportation Improvement Program (TIP) and the metropolitan transportation plan for El Paso. Included in the report is a brief overview of the emission estimation methodology and the 24-hour traffic assignments used in the analyses; the methods used to estimate the seasonally adjusted time-of-day vehicle miles of travel and associated operating speeds; the estimation of the emission rates using the EPA's MOBILE5a program; and brief outlines of the method used to develop the emission estimates using the MOBILE5a emission rates and comparisons of the emission estimates for the Build and No-Build Options. An appendix presents the emission rates developed for conformity analysis.

Development of Emission Estimates for the Conformity Analysis of the Victoria FY-94 TIP and 2015 Metropolitan Plan

Jimmie D. Benson, George B. Dresser, Charles E. Bell, and J. Michael Heath, Texas Transportation Institute. Research Study Number 0-1375, Report 1375-3. Sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. July 1994.

This report documents the mobile source emissions estimation methodology used for the conformity analysis of the Transportation Improvement Program (TIP) and the metropolitan plan for Victoria County. Included in the report is a brief overview of the emissions estimation methodology and the 24-hour traffic assignments used in the analyses; the methods used to estimate the seasonally adjusted time-of-day vehicle miles of travel and associated operating speeds; the estimation of the emission rates using the EPA's

MOBILE5a program; and brief outline of the method used to develop the emissions estimates using the MOBILE5a emission rates and comparisons of the emissions estimates for the Build and No-Build Options. An appendix presents the emission rates developed for conformity analysis.

DEVELOPMENT OF EMISSION ESTIMATES FOR THE CONFORMITY ANALYSIS OF THE JOHRTS FY-94 TIP

Jimmie D. Benson, George B. Dresser, and Charles E. Bell, Texas Transportation Institute. Research Study Number 0-1375, Report 1375-4. Sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. July 1994.

This report documents the mobile source emissions estimation methodology used for the conformity analysis of the Transportation Improvement program (TIP) and the Long Range Plan (LRP) for (Victoria County/JOHRTS/El Paso). Included in the report is a brief overview of the emissions estimation methodology and the 24-hour traffic assignments used in the analyses; the methods used to estimate the seasonally adjusted time-of-day vehicle miles of travel and associated operating speeds; the estimation of the emission rates using the EPA's MOBILE5a program; and a brief outline of the method used to develop the emissions estimates using the MOBILE5a emission rates and comparison of the emissions estimates for the Build and No-Build Options. An appendix presents the emission rates developed for the conformity analysis.

A CRITICAL ANALYSIS OF SKETCH-PLANNING TOOLS FOR EVALUATING THE EMISSION BENEFITS OF TRANSPORTATION CONTROL MEASURES

Jason A. Crawford and Raymond A. Krammes, Texas Transportation Institute. Research Study Number 0-1279, Report 1279-5. Sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. December 1993.

The two premier sketch planning tools used for evaluating transportation control measures are the Systems Applications International (SAI) method and the San Diego Association of Governments (SANDAG) method. Both methods were adapted to an available spreadsheet for easy use and modification. The SAI method required full programming in the spreadsheet, whereas the SANDAG method, originally developed for spreadsheet use, required only minor revisions.

A critical analysis, base scenario comparison, and sensitivity analysis were performed on the SAI and SANDAG methods. Results of the sensitivity analysis showed that the tools are most sensitive to the scope descriptors and work-related variables.

The report concludes that (1) recent work in the field has greatly advanced the state-of-the-practice; (2) the SAI method proved to be a better analysis tool than the SANDAG method; and (3) although sketch planning tools are gross estimating techniques, they are currently the best TCM analysis tools.

User's Guide for the Texas Mobile Source Emission Estimation Software: PREPIN, POLFAC5A, COADJ, IMPSUM, and SUMALL

Charles E. Bell, Jimmie D. Benson, and George B. Dresser, Texas Transportation Institute. Research Study Number 0-1279, Report 1279-2. Sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. October 1993.

This research report represents the latest revisions to the software, PREPIN, POLFAC5A, COADJ, IMPSUM, and SUMALL. The previous dates of revision are November 1992 and January, April, and July 1993. This report is presented as a user's guide; operating instructions are provided for each program. The mainframe programs were developed to estimate mobile source emissions and vehicle miles traveled (VMT). The PREPIN program allows the analyst to factor a 24-hour assignment to estimate the VMT and speeds for a subject time period. The POLFAC5A program is used to apply MOBILE5 to obtain emissions factors. COADJ, a special utility program, combines emission factors from three applications of the POLFAC5A program to produce a new set of emission factors. IMPSUM facilitates the computation of emissions by using the emission factors from POLFAC5A and COADJ. Lastly, SUMALL sums the emission results from two or more time periods plus diurnals. IMPSUM and SUMALL have the additional capability of producing gridded emission estimates.

An Outline of Transportation-related Requirements for Compliance With the Clean Air Act Amendments of 1990

Amy Stephenson and George B. Dresser, Texas Transportation Institute. Research Study Number 0-1279, Report 1279-1. Sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. February 1993.

The Clean Air Act Amendments (CAAA) of 1990 require areas designated as being in nonattainment of the National Ambient Air Quality Standards to reach attainment by certain dates, depending on their measured air quality, or design value, for a particular criteria pollutant.

Texas has four urban areas and one county area in nonattainment for various pollutants. El Paso is in nonattainment for particulate matter (PM-10), carbon monoxide (CO),

and ozone (O3). The Dallas-Fort Worth, Beaumont-Port Arthur, and Houston-Galveston-Brazoria areas are in nonattainment for ozone. Collin County is in nonattainment for lead.

Transportation-related tasks of meeting the air quality goals are significant because mobile sources may account for as much as 50 percent of the ozone and 90 percent of the carbon monoxide pollution on a national scale. Because lead is predominantly a stationary source problem, this report does not deal with the requirements for Collin County.

This report contains an outline of the transportation-related requirements for emissions inventories, State Implementation Plan (SIP) submittals, implementation strategies, and possible sanctions for failure to meet the requirements. Several of the sections, particularly the SIP sections, are repetitive in an effort to save the reader from an unreasonable amount of cross-referencing information between sections. A list of the acronyms used in this report and a list of suggested guidance documents are included at the end of this report.

New regulations and interpretations of the CAAA are still being issued with some frequency. As a result, the due dates and some of the requirements listed are subject to changes.

SUMMARY DOCUMENTATION FOR THE TEXAS TRAVEL DEMAND PACKAGE

Tom A. Williams and George B. Dresser, Texas Transportation Institute. Research Study Number 2-10-92-1375, Report 1375-1. Sponsored by the Texas Department of Transportation. December 1992.

The statewide practice of urban travel forecasting in Texas is described. An overview of methods practiced and theoretical basis for travel modeling is presented in a brief format. Each of the four steps used in the Texas Package travel modeling process is described. TRIPCAL5, the Texas Package trip generation method, is summarized. Trip distribution practice using the Texas Package ATOM model is included. Finally, the Texas Package methodology using the iterative traffic assignment process is described.

OVERVIEW

TRAVEL FORECASTING GUIDELINES

Patricia Bass, Dennis G. Perkinson, Brigitta Keitgen, and George B. Dresser, Texas Transportation Institute. Research Study Number 0-1235, Report 1235-14. Sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. October 1994.

Implementing transportation improvements requires a significant effort that may involve several levels of planning; social, economic and environmental documentation; geometric and structural design; operations analysis; signalized intersection design; and/or pavement design. Accurate and timely traffic estimates and forecasts are basic to the entire transportation planning process and are essential to enable the Texas Department of Transportation (TxDOT) to effectively meet the mobility needs of the state. This guide provides an introduction to the transportation planning and travel demand forecasting requirements and establishes the policies, processes and methodologies for developing traffic forecasts for the various stages of TxDOT project development.

INTEGRATING TRANSPORTATION AND LAND USE PLANNING

Susan J. Obermayer, Vergil G. Stover, and George B. Dresser, Texas Transportation Institute. Research Study Number 0-1235, Report 1235-15. Sponsored by the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. August 1994

Changes in the transportation system have a large influence on urban development patterns. The location, type, and intensity of urban land uses also affect the urban street and highway system. Various federal and state initiatives have been taken to more closely link transportation and land use. These include the following:

- The Traffic Congestion Management System (CMS) mandated by the Intermodal Surface Transportation Efficiency Act (ISTEA). The CMS regulations specifically state that state and local agencies must address existing congestion and avoid potential future congestion. This clearly implies that the impact of land use and development decisions on transportation must be more effectively addressed than in the past.

- State-mandated growth management requirements such as those in Oregon, Washington, Florida, and Vermont.

- State-mandated local planning which must meet state criteria as those in Florida, Hawaii, Maine, New Jersey, Rhode Island, and Oregon.

- State-mandated congestion management which requires that the impact of proposed development must be assessed and provides penalties if development that degrades congestion is approved by a local government (California).

- Access management practices administered by the state highway agency which are designed to protect the public investment in major state roadways (Colorado, Florida, and New Jersey).

In order to address traffic congestion problems, many municipalities have implemented travel demand ordinances which are intended to reduce drive-alone auto use and encourage ridesharing and transit. In other locations, such requirements have been, or are being, implemented in response to federal clean air requirements.

GIS Protocol and Data Structures for the Texas Travel Demand Package

Tom A. Williams and George B. Dresser, Texas Transportation Institute. Research Study Number 7-947, Report 947-8. Research performed for the State of Texas. August 1994.

The Texas Travel Demand Package is a set of computer programs used to perform travel demand analysis and forecasting. This document demonstrates the applicability of a Geographic Information System for Transportation to the Texas Travel Demand Package. First, a brief overview of GIS is described. Then, variables and functions which can be directly applied to a GIS are outlined. A description of the possible enhancement to the functionality and efficiency of the travel demand forecasting environment follows. Finally, an annotated bibliography of GIS applications in travel demand modeling is listed.

Manual for the Interactive Training System for Texas Travel Models

George B. Dresser and Tom A. Williams, Texas Transportation Institute. Research Study Number 7-947, Report 947-7. Research performed for the State of Texas. October 1993.

The Texas Package of travel demand forecasting programs is a mainframe mathematical model for forecasting travel in urban areas in the state of Texas. Interactive Lotus 1-2-3 spreadsheet templates have been developed to provide case study examples of the mathematical functions used in the Texas Package.

This manual is intended for use by the Texas Department of Transportation offices, Metropolitan Planning Organizations, municipalities, counties, and consultants contracted by public agencies in the state of Texas for training employees in the theory and application of the Texas Package travel demand forecasting model.

The information contained in the Lotus 1-2-3 modules and this manual can be used to train new staff members or to refresh employees who have been minimally exposed to the travel demand forecasting process. The models and formulas contained in the spreadsheet templates are not solely applicable to the Texas models but are examples of standard travel modeling practices used in other states as well.

TRAFFIC FORECASTING REQUIREMENTS BY PROJECT TYPE

Patricia Bass and George B. Dresser, Texas Transportation Institute. Research Study Number 0-1235, Report 1235-8. Sponsored by the Texas Department of Transportation. October 1992.

The method used to prepare a traffic forecast needs to relate to the type of project for which the forecast is prepared. This report describes the various types of projects for which the Texas Department of Transportation uses traffic forecast data. For each project category, the type of traffic forecast data needed to perform the required analyses is identified and the appropriate forecasting procedure and level of forecast accuracy that can be expected is described. The project categories and forecasting requirements discussed include urban transportation planning; feasibility studies; advanced planning; environmental documentation; and geometric, signalized intersection, pavement and bridge design.

TEXAS TRANPLAN APPLICATION GUIDE

Tom A. Williams and George B. Dresser, Texas Transportation Institute. Research Study Number 2-10-88-947, Report 947-6. Research performed for the State of Texas. August 1992.

TRANPLAN is a package of separate, distinct programs which perform travel demand analysis. TRANPLAN can be used to perform the traditional four-step transportation forecasting process: trip generation, trip distribution, mode choice, and traffic assignment.

This guide is intended for use by the Texas Department of Transportation offices, Metropolitan Planning Organizations, municipalities, counties, and consultants contracted by public agencies in the state of Texas. The guide should be used in conjunction with the TRANPLAN reference manual and the Highway Network Information Systems (HNIS) reference manual.

The information in this manual can be used to train new TRANPLAN users, refresh users who have been minimally exposed to TRANPLAN, and serve as a "template" to aid experienced users. This guide, however, is not intended to provide a comprehensive description of all the capabilities of the TRANPLAN software.

Guidelines for Conducting Intercity Highway Route Studies, Informational Report No. 8

Robert W. Stokes and George B. Dresser, Texas Transportation Institute. Research Study Number 2-10-90-1235, Report 1235-9. Cooperative research program of the Texas Transportation Institute and the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. September 1991.

This document provides the Texas Department of Transportation the initial step in developing a methodology for conducting intercity route studies. It is intended to assist the analyst in identifying the key factors that should be addressed in intercity route studies and to provide guidance in selecting the appropriate procedure(s) for evaluating these factors. In many cases the procedures presented have not been extensively tested and should be used with caution; in some cases, the procedures are either overly simplistic, in the development stage, or nonexistent. Therefore, numerous "gaps" and caveats exist; recommendations for filling these gaps are enumerated whenever appropriate.

The guide consists of five chapters, four of which correspond to the four-step framework recommended for conducting intercity route studies. Several appendices provide guidelines concerning origin-destination studies, recommended data sources, descriptions of alternative methodologies, and additional documentation for selected topics which are treated in less detail in the main text.

Traffic Load Forecasting for Pavement Design

Anthony J. Vlatas and George B. Dresser, Texas Transportation Institute. Research Study Number 2-10-90-1235, Report 1235-1. Cooperative research program of the Texas Transportation Institute and the Texas Department of Transportation in cooperation with U.S. Department of Transportation, Federal Highway Administration. August 1991.

When a pavement structure fails prematurely, the constructing agency must pay millions of dollars in traffic control and construction costs to rehabilitate or reconstruct the pavement sooner than had the pavement survived its design life. The money required to rehabilitate or reconstruct the pavement could have been put to alternative uses during the remaining years of the pavement's design life; but because the money must be spent when the pavement actually ceases to provide adequate service, the opportunity to apply the much needed capital elsewhere is lost. A primary determinant of a pavement's actual service life is the traffic loading applied to the pavement. Consequently, an important consid-

eration in pavement structural design is a forecast of the traffic loading expected to be applied to the pavement structure during its design life. This research evaluated the Texas State Department of Highways and Public Transportation's traffic load forecasting procedures. The research found that traffic load forecast accuracy could be improved by more than 30 percent from the current levels by conducting 24-hour manual vehicle classification sessions at specific pavement project sites and by more than 85 percent by conducting week-long weigh-in-motion (WIM) sessions at specific pavement project sites. The research shows that if forecast accuracy were improved by the amounts indicated above, fewer pavements would typically fail prematurely; and while some pavements would still fail prematurely despite improved forecasts, these pavements would have longer lives than under current practice. The research found that the cost to improve traffic load forecasts is justified by the benefits received in return for almost all pavement reconstruction projects and most major pavement rehabilitation projects.

A Comparison of Microcomputer Packages for Network-based Highway Planning

D.M. Chang, V.G. Stover, and G.B. Dresser, Texas Transportation Institute. Research Number 2-10-87-1110, Report 1110-3. Cooperative research program of the Texas Transportation Institute and the State Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. October 1988.

In an effort to meet the increasing requirement to perform transportation studies for a small geographic area within a major urban area, existing microcomputer software was evaluated for suitability to perform subarea analysis and its compatibility with the output from the Texas Travel Demand Package. The initial phase of the study included a detailed literature and software search. Eleven potential transportation software packages were identified and five packages were chosen for further in-depth evaluation. They are TRANPLAN/NEDS (11 program diskettes and user's manual); MicroTRIPS (nine program diskettes and user's manual); MINUTP (five demonstration diskettes and user's manual); MOTORS (11 diskettes and user's manual); and TransPro (two demonstration diskettes and user's manual). Information was provided by each vendor in January 1987. TRANPLAN, MicroTRIPS, and MINUTP packages are the comprehensive software systems for transportation planning and parallel UTPS/PLANPAC in functional capability. However, MicroTRIPS and MINUTP are evaluated as being less compatible with the Texas Traffic Assignment Package and as having fewer capabilities than TRANPLAN. MOTORS package has limited network plotting capabilities and functional network building capabilities. TransPro package is too simple to be compatible with the network-based analysis used by the Texas Travel Demand Package. Finally, the TRANPLAN/NEDS packages were selected for suitability to perform subarea analysis and for compatibility with the output from the Texas Travel Demand Package.

FEASIBILITY OF VALIDATING THE SHIRLEY HIGHWAY HOV LANE DEMAND MODEL IN TEXAS

R.W. Stokes, and J.D. Benson, Texas Transportation Institute. Research Study Number 2-10-87-1103, Report 1103-1. Cooperative research program of the Texas Transportation Institute and the State Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration, July 1987.

This research report presents an assessment of the feasibility of validating the Shirley Highway (I-395) High-Occupancy Vehicle (HOV) Lane Demand Model in Texas. The results of the study suggest that the Shirley Model has not been sufficiently developed at this time to warrant additional testing outside the Shirley corridor. In fact, additional testing within the Shirley corridor will be needed to determine whether the preliminary model represents the "best" model that could be estimated from the data set and whether the model can accurately replicate travel choice decisions observed in the Shirley corridor. A review of currently available alternatives to the Shirley Model is also presented. While these procedures could be used to develop a range of demand estimates that appear reasonable for many sketch planning applications, they are still fairly crude; and more refined estimation procedures are clearly needed. It is recommended that any additional efforts to validate the Shirley Model in Texas be undertaken through a separate research project and that local efforts focus on the development of HOV lane demand estimation procedures based on experiences gained in operating HOV facilities in Texas. These two independent, though clearly complementary, efforts should be closely coordinated to facilitate a possible merging of efforts.

SUBAREA PROCEDURE GUIDE

Charles W. Zipp and Charles E. Bell, Texas Transportation Institute. Prepared for the State Department of Highways and Public Transportation. August 1985.

Procedures for running subarea windowing and subarea focusing are given in a step-by-step format.

TRAVEL DEMAND MODELING: AN OVERVIEW

C.W. Zipp and C.E. Bell, Texas Transportation Institute. Study Number 2-10-80-1170, Urban and Regional Transportation Studies. Prepared for the State Department of Highways and Public Transportation. August 1981.

This document presents an overview of the Travel Demand Models used in Texas by the State Department of Highways and Public Transportation. The intent is to make clear to potential beneficiaries of the services rendered by the Transportation Planning Division, SDHPT, what the models do, what inputs they need, and the printed output available. In

the case of the latter, efforts are made to describe each table, its contents, and the analytical significance.

PROCEDURE LIBRARY FOR TRIP DISTRIBUTION AND TRAFFIC ASSIGNMENT, TECHNICAL NOTE

C.E. Bell, J.D. Benson, and C.W. Zipp, Texas Transportation Institute. Study Number 2-10-80-1170, Urban and Regional Transportation Studies. February 1980.

The Procedure Library has been prepared with the objective of simplifying the process of running trip distributions and traffic assignments. The procedures accomplish this objective by supplying all DD statements which are normally used to run a job. While the specific tape volumes must be supplied through parameter names, where a data set is used in two or more steps in a procedure, the volume name and, in some cases, the data set name are required only for one parameter. (This report is not current and should be used only as a general guide.)

DEVELOPMENT AND CALIBRATION OF TRAVEL DEMAND MODELS FOR THE HOUSTON-GALVESTON AREA

Texas Transportation Institute and Barton-Aschman and Associates, Inc. Prepared for the Metropolitan Transit Authority, Houston, Texas. July 1979.

Travel demand models have been developed, calibrated, and validated for the Houston-Galveston area. These models are somewhat unique in that they were developed and validated without the benefit of a traditional, full-scale origin-destination survey data base.

In other words, the study is a "synthetic" study. The preceding 1970 Houston-Galveston Regional Transportation Study was the first major application of a synthetic study approach. Since that time, synthetic study techniques have been successfully utilized in numerous urban transportation studies in Texas. By eliminating the traditional, full-scale O-D surveys, synthetic studies can be performed at substantially less cost than traditional studies.

The report is divided into two sections. Section 1 describes the zone structure and highway network, the data base, the trip generation models, the trip distribution model, and the highway assignment results. Section 2 describes the model description and the calibration methodology the calibrated models the sensitivity analysis and the validation of automobile vehicle trips.

Section 1 was prepared by the Texas Transportation Institute. Section 2 was prepared by Barton-Aschman and Associates, Inc.

Urban Transportation Study, Data Preparation Instructions, Zonal Base Year and Forecast Data

Transportation Planning Division, State Department of Highways and Public Transportation. 1977.

This manual is intended to present guidelines as to the type and quality of forecasted data required by the trip generation models currently being used by the Transportation Planning Division; to explain the implications associated with various income, dwelling unit, and land use/employment forecasts to insure the compatibility of the data with the models such that logical zonal travel is produced; and to indicate typical problem areas which commonly occur as a result of improper forecasting techniques.

General Aspects of H-GRTS Travel Demand Modeling

Oliver F. Stork, Study Director, Houston-Galveston Regional Transportation Study. H-GRTS, P.O. Box 187, Houston, TX 77001. January 1977.

This report is a general presentation of the travel demand modeling techniques used by the Houston-Galveston Regional Transportation Study Office for analysis of its study area. A discussion of the results of the modeling procedure is included. This discussion of the modeling technique is intended to give insight into how the results are reached. For a more detailed explanation of the methodology used than is presented in this discussion, a list of references is included.

Urban Transportation Study Procedures

J.D. Benson, V.G. Stover, and M.F. Teniente, Texas Transportation Institute. Research Study Number 2-10-74-17, Report 17-3F. Cooperative research program of the Texas Transportation Institute and the State Department of Highways and Public Transportation of Texas in cooperation with the U.S. Department of Transportation, Federal Highway Administration. August 1975.

Study Number 2-10-74-17, "Urban Transportation Study Procedures," was directed toward providing continuing technical support in conducting urban transportation studies throughout the state. Assistance was provided in analysis and forecasting techniques relative to urban transportation studies. The maintenance and modification of computer programs previously developed was performed under this study.

URBAN TRAVEL FORECASTING

J.D. Benson and V.G. Stover, Texas Transportation Institute. Research Study Number 2-10-71-167, Report 167-9F. Cooperative research program of the Texas Transportation Institute and the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. August 1974.

Assistance was provided in the analysis and forecasting techniques relative to urban transportation studies; the maintenance and modification of computer programs previously developed for and used by the Texas Highway Department; the preparation of additional computer programs; and the implementation of research findings and the use of models and computer programs developed under this study or its predecessors (i.e., Studies 2-8-63-60 and 2-10-68-119).

The accuracy of home interview data in estimating zonal trip ends and travel patterns was investigated using 100 percent survey data from three zones. These analyses indicated disturbingly low probabilities of reasonably accurate estimates of either zonal trip ends or travel patterns using traditional sampling rates. These analyses suggest, however, that an estimating equation (regression model or cross-classification rates) based on either disaggregate or aggregate data will provide more reliable estimates of zone trip ends than the O-D survey directly. These analyses also indicated that significant cost savings could be achieved while still maintaining acceptable accuracy of trip generation estimates through more statistically efficient procedures and the knowledge of experienced analysts. Based largely on these findings, a synthetic study was proposed, designed, and implemented in a cooperative efforts between the Texas Highway Department and the Texas Transportation Institute.

A preliminary macroscopic analysis of the temporary stability of trip generation rates indicates that these rates have been increasing as a result of a greater propensity to travel and changes in socioeconomic characteristics. A preliminary evaluation of induced traffic on new highway facilities suggests that this element may account for a significant portion of the traffic on many new facilities and may partially explain the tendency to underestimate traffic on such facilities.

TRAFFIC PROJECTION AND ASSIGNMENT

V.G. Stover and J.D. Benson, Texas Transportation Institute. Research Study Number 2-10-68-119, Report 119-3F. Prepared in cooperation with the Texas Highway Department and the U.S. Department of Transportation, Federal Highway Administration. September 1971.

Two traffic assignment packages were developed for use on the Texas Highway Department's IBM 360-50 Computer System. The Texas Small Network Package, which will accommodate small networks of up to 4,000 nodes, implements a new algorithm which allows the trees to be built and the network simultaneously loaded. The Texas Large Network Package, which will accommodate a network of up to about 16,000 nodes, uses a minimum path algorithm which is considerably more efficient than any previously used. A battery of computer programs for trip distribution was also developed and adopted by the Texas Highway Department.

The accuracy of employment and non-home trip ends from home interviews was investigated. The accuracy of all-or-nothing traffic assignments in estimating turn movements was also investigated.

Home interviews were conducted by the Texas Highway Department in 100 percent of the dwelling units in three adjacent zones in San Antonio. A preliminary analysis of the 100 percent data indicates that very high sampling rates are necessary in order to estimate the number of trips with a small confidence limit.

PROGRAM DOCUMENTATION MANUAL FOR THE TEXAS TRIP DISTRIBUTION PACKAGE

J.D. Benson, D.F. Pearson, C.E. Bell, and V.G. Stover, Texas Transportation Institute. Research Study Number 2-10-71-167, Report 167-2. Sponsored by the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. November 1971.

The Texas Trip Distribution Package is a collection of computer programs designed to performed trip distributions featuring the application of a constrained interactance model. Other programs, available in the package, provide full support. The purpose of this manual is to provide data processing personnel with a link between the Operating Manual for the Texas Trip Distribution Package (Research Report 167-1) and the programs contained in the package. The manual describes the operation of the package and provides flow charts of the programs in the package. Cross references for significant variables and arrays used in the package and formats for all data sets and data cards associated with the package are provided.

FINAL-SUMMARY REPORT ON THE TRAFFIC ASSIGNMENT STUDY

V.G. Stover, Texas Transportation Institute. Research Study Number 2-8-63-60, Report 60-14.

Sponsored by the Texas Highway Department in cooperation with the U.S. Department of Transportation, Federal Highway Administration. October 1969.

The final-summary report on Study Number 2-8-63-60 is intended to cover the highlights of the four-year study. The several objectives of the study are listed together with a summary of how each was met.

The various research reports and technical memoranda which evolved from the project are also listed. The major contributions to the state-of-the-art traffic assignment are briefly outlined to provide an overview of the project.

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