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16. Abstract This report presents the results of a series of interviews conducted from 1989 to 1991 with district, division, and administrative staff of the Texas Department of Transportation (TxDOT). The purpose of these interviews was to obtain information on TxDOT transportation planning practices and procedures, to get an understanding of how the various districts and divisions viewed TxDOT planning practices, and to obtain opinions and perceptions about how well these practices were meeting the various planning needs of the Department. The interviews focused on the six research areas to be studied during this project: (1) state-of-the-art planning techniques, (2) traffic forecasting requirements, (3) traffic data collection and analysis, (4) rural traffic forecasting, (5) urban traffic forecasting, and (6) intercity route studies. Also, interviews were conducted with selected departments of transportation in other states to compare TxDOT practice with other state practices.			
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**TEXAS DEPARTMENT OF TRANSPORTATION
TRAFFIC FORECASTING PRACTICES**

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IMPLEMENTATION STATEMENT

This research report documents the traffic forecasting practices and procedures of the Texas Department of Transportation (TxDOT) from 1989 through 1991. The report discusses TxDOT's organizational structures for traffic forecasting in comparison with those of other states, methods of data collection and analysis, policy and administrative requirements of traffic data, district requirements for traffic data, and rural and intercity traffic forecasting. A comprehensive analysis of these areas can enable TxDOT to improve and advance traffic forecasting practices.

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 the project.

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SUMMARY

Significant changes are taking place in state and urban transportation planning activities. Although emphasis has been on short-range problem solving and decision making, an increasing number of states have developed or are updating long-range comprehensive highway plans. Transportation planning has become an integral part of this decision-making process. The complex relationships between transportation, economic development, and demographic changes are also significantly affecting state and local transportation needs and requirements. These recent changes in the emphasis of statewide transportation planning have presented planners, managers, and decision makers with an enormous challenge. The combined effects of these factors will require expanding the scope and improving the quality of the state's transportation planning techniques.

This report presents the results of a series of interviews conducted from 1989 to 1991 with district, division, and administrative staff of the Texas Department of Transportation (TxDOT). The purpose of these interviews was to obtain information on TxDOT transportation planning practices and procedures, to get an understanding of how the various districts and divisions viewed TxDOT planning practices, and to obtain opinions and perceptions about how well these practices were meeting the various planning needs of the Department. The interviews focused on the six research areas to be studied during this project: (1) state-of-the-art planning techniques, (2) traffic forecasting requirements, (3) traffic data collection and analysis, (4) rural traffic forecasting, (5) urban traffic forecasting, and (6) intercity route studies. Also, interviews were conducted with selected departments of transportation in other states to see how TxDOT practice compared with other state practices.

Findings and recommendations are organized into the following chapters:

- **Organizational Structures for Traffic Forecasting** summarizes the organizational traffic forecasting structures in place at TxDOT and at three other state DOTs facing similar problems. Expanding the responsibilities of the central forecasting unit and transferring traffic forecasting responsibility to local agencies (districts, MPOs) were suggested for improvement.

- **TxDOT Traffic Data Collection and Analysis** presents a summary of traffic data collection and analysis programs in the state of Texas during the study period. While these programs provided extensive data concerning the magnitude and composition of traffic on the state's highway system, there were no comparably comprehensive programs to compile the additional data needed for travel demand modeling, either at the state or local level.
- **TxDOT Policy and Administrative Requirements of Traffic Data** were developed as a result of a survey of TxDOT division staff and FHWA staff to determine the effectiveness of traffic forecasting and data collection programs at the time this study was conducted. The findings and conclusions of the surveys are reported.
- **TxDOT District Office Requirements for Traffic Data** summarizes a series of oral interviews with district engineers, district design engineers, district planning engineers, and district traffic engineers from each TxDOT District Office. The interviewer's questions (see Figure 10) centered around the focus areas of the project.
- **Rural, Intercity, and Statewide Traffic Forecasting** presents a review of practices in these areas of traffic forecasting. The problems and shortcomings associated with the practices are discussed, and recommendations for improvement are made.

CHAPTER 1

INTRODUCTION

BACKGROUND AND PURPOSE OF THIS REPORT

Significant changes are taking place in state and urban transportation planning activities. Although emphasis has been on short-range problem solving and decision making, an increasing number of states have developed or are updating long-range comprehensive highway plans. This trend is expected to continue as states assume increasing responsibilities for planning and funding highway programs.

The importance of a multimodal approach to transportation planning and of planning as an integral part of the overall management and decision-making processes is becoming more widely accepted. The complex relationships between transportation, economic development, and demographic changes are also significantly affecting state and local transportation needs and requirements. Changes in the emphasis of statewide transportation planning have presented planners, managers, and decision makers with an enormous challenge. The combined effects of these factors have required expanding the scope and improving the quality of the state's transportation planning techniques.

This research project focused on improving transportation planning practice and procedures in six specific research areas: (1) state-of-the-art planning techniques, (2) traffic forecasting requirements, (3) traffic data collection and analysis, (4) rural traffic forecasting, (5) urban traffic forecasting, and (6) intercity route studies. These research areas are described more completely below. An understanding of the overall scope of this project is helpful in evaluating the information provided in this report. The results reported in this report were used to guide the direction of the project and help identify areas of greatest concern to the Department.

State-of-the-Art Planning Techniques

This research area documents Department practice from 1989 to 1991 and the practice from selected state DOTs and assesses where TxDOT is in transportation planning practice compared to where it would like to be. How does Texas planning practice compare with state-of-the-art planning

practice? How does Texas practice compare with the best work being done by other states?

Traffic Forecasting Requirements

The method used to prepare a traffic forecast needs to relate to the type of highway or bridge project (new highway, major reconstruction, minor reconstruction, RRR, etc.) for which the forecast is prepared. A relationship needs to be established between the type of project, the project's scale and cost, and the forecasting procedure used. An understanding of the nature of the decision(s) to be made using these forecasts is needed. A quick-response forecast procedure may be appropriate to answer questions in the initial stages of project development but would not be an appropriate procedure for the environmental or design stage. This research area will identify the traffic data requirements and the level of accuracy that can be expected for each forecasting procedure.

Traffic Data Collection and Analysis

The Department maintains an extensive traffic data collection and analysis program. TTI staff researched whether the program could be strengthened through improved statistical design of traffic data collection procedures and whether the traffic data collection resources could be better balanced. Resources do not permit the Department to collect all the traffic data that some engineers think desirable. This research area examined the traffic data collection program in detail and developed recommendations for improvement. One of the primary uses of traffic data and traffic forecasts is to estimate future year design hour volumes. These estimates are frequently derived from 24-hour traffic counts. The relationship between 24-hour volume counts and hourly volume estimates depends on several factors including flow rate, peak-hour factors, lane utilization factors, proportion of traffic in peak direction, proportion of trucks, proportion of peak hour to 24-hour, etc. Traffic data are also used to estimate these factors and to forecast how these factors are changing over time. Other traffic data such as vehicle classifications and truck weights are used in the design process. Where traffic data are collected is as important as which traffic data are collected. This research area used findings of the traffic forecasting requirements research area to evaluate the Department's data collection program and develop recommendations for improving the effectiveness of the program.

Rural Traffic Forecasting

Rural highways comprise the majority of the state highway system. Forecasting future AADT for rural sections is usually accomplished by simple linear regression of historical traffic counts for the section of interest or, if counts are not available, by a simple linear regression of the counts from the most appropriate permanent count station(s). For many rural areas this procedure is adequate, particularly if the historical data fit a linear model. For locations where the data do not fit a linear model, and for locations where the traffic will be impacted by identifiable demographic and economic changes, this procedure provides less than optimum results. It is recognized that the same emphasis on demographic, employment, and land use forecasting used as part of the process to prepare urban traffic forecasts cannot be expected for rural forecasts. However, to not consider socioeconomic information, when available, for preparing rural traffic forecasts seems shortsighted. This research area uses the findings of the traffic forecasting requirements and the traffic data collection and analysis research areas to evaluate present procedures, recommend areas for improvement, and develop and implement improved procedures for rural traffic forecasting.

Urban Traffic Forecasting

The Department has had a longstanding research relationship with TTI for the development and enhancement of urban traffic forecasting models and related procedures. Nevertheless, TTI staff researched whether or not the Department's models are state-of-the-art. The models may not be as effective as models being used in other parts of the nation. This research area assesses the area of urban traffic forecasting. It is expected that major improvements and enhancements to the urban traffic planning process will be implemented as part of this research area. With more urban areas than any other state in the nation, Texas should have an outstanding urban traffic forecasting process.

Intercity Route Studies

In recent years, the Department has received several requests for intercity route studies. There are two aspects to these requests: (1) the need to achieve improved traffic movement, and (2) the need to achieve an economic benefit. For example, the proposed new roadway in the Austin-San Antonio corridor would divert traffic from Interstate 35 and improve the accessibility of thousands

of acres of undeveloped land. The proposed new roadway in the Austin-College Station corridor would reduce travel time, provide a higher level facility, and stimulate research cooperation between The Texas A&M University System and The University of Texas System. Responding to individual route study requests mandates a great deal of staff time and expense. The Department currently does not have an intercity highway plan. The Department also needs to respond to proposals for development of other intercity transportation modes, such as the proposed intercity high-speed rail project. Specific projects conducted in this research area will enhance the methodology used to develop the initial intercity route plan.

REPORT ORGANIZATION AND STUDY METHOD

In addition to this introductory chapter, this report consists of the following five chapters: Organizational Structures for Traffic Forecasting; TxDOT Traffic Data Collection and Analysis; TxDOT Policy and Administrative Requirements of Traffic Data; TxDOT District Office Requirements for Traffic Data; and Rural, Intercity, and Statewide Traffic Forecasting.

This report presents the results of a series of interviews conducted from 1989 to 1991 with district, division, and administrative staff of the Texas Department of Transportation. The purpose of these interviews was to obtain information on TxDOT transportation planning practices and procedures, to get an understanding of how the various districts and divisions viewed TxDOT planning practices, and to obtain opinions and perceptions about how well these practices met the various planning needs of the Department. The interviews focused on the six research areas to be studied during this project. Also, interviews were conducted with selected departments of transportation in other states to determine how TxDOT practice compared with other state practices.

Chapter 2 compares the TxDOT organization for traffic estimation and forecasting with the organizations in several other states and compares the planning staffs among the states interviewed. Chapter 3 provides a discussion of the TxDOT traffic data collection procedures. A reading of this chapter will assist in understanding the responses to the interviews in Chapters 4 and 5. Chapters 4 and 5 contain a summary of the administrative, division, and district interviews conducted. The administrative and division interviews are of interest because they contain a broader insight into the varied uses and applications of traffic data and traffic forecasts by the Department. The chapter on

the district perspective contains the most recommendations as to areas where improvement in planning practice may be most appropriate. The districts were remarkably similar as to the application of traffic estimates and forecasts, which perhaps ought to be expected since the missions and functions of the various districts are similar although differing in magnitude. The districts' senior staff had very similar views as to overall quality of transportation planning services provided by the Department. A limited discussion of urban planning practices is presented in this report. Although appropriate questions were asked, almost no one outside the Transportation Planning Division had in-depth knowledge of urban traffic forecasting procedures. The last chapter provides information on the Department's rural and intercity forecasting practices and makes several suggestions as to how these practices might be strengthened.

Again, the information obtained during these interviews and reported on within this report were used to provide direction and guidance to the project.

CHAPTER 2

ORGANIZATIONAL STRUCTURES FOR TRAFFIC FORECASTING

GENERAL

This chapter summarizes the organizational traffic forecasting structures in place from 1989 to 1991 at TxDOT and three state DOTs. The discussion addresses basic organizational structures, the mission(s) of the traffic forecasting units of state highway agencies, staffing and salary levels of traffic forecasting units, and the general strengths and weaknesses of organizational structures as they relate to the traffic forecasting function. This chapter concludes with a summary of the strengths and weaknesses of TxDOT's organizational structure and a discussion of possible alternative organizational arrangements. These observations and recommendations are based on conditions as they existed at the time the interviews were conducted in 1989 and 1990. This report documents the initial investigations on which much of the subsequent work for Project 1235 was predicated and serves as a historical reference. Revisions to update this report to 1994 conditions are not appropriate.

TEXAS DEPARTMENT OF TRANSPORTATION

Organizational Structure

The TxDOT organizational structure in place at the time of this study is shown in Figure 1. The Transportation Planning Division (now the Transportation Planning and Programming Division) was responsible for the Department's transportation planning functions. The Transportation Planning Division consisted of the Administrative Operations, Transportation Systems Planning, and Research and Development Sections. As shown in Figure 2, the Transportation Systems Planning Section was responsible for the Department's traffic data analysis and traffic forecasting functions. Traffic data collection was the responsibility of the Research and Development Section.

The specific responsibility for traffic data analysis and traffic forecasting rested with the Traffic Analysis Subsection of the Transportation Systems Planning Section (Figure 3). The Traffic Analysis Subsection prepared traffic forecasts for the Transportation Commission, for TxDOT Administration and for the Department's District offices for use in evaluating and ranking proposed

projects, for preliminary engineering, for engineering design, and for numerous other applications. The Traffic Analysis Subsection also prepared traffic forecasts for all but two of the state's urbanized areas (the MPOs for the Houston and Dallas-Fort Worth urbanized areas prepare their own travel forecasts in cooperation with TxDOT). Other responsibilities of the Traffic Analysis Subsection included preparing traffic forecasts for corridor/site analyses and developing 20-year traffic forecasts for all rural state highways.

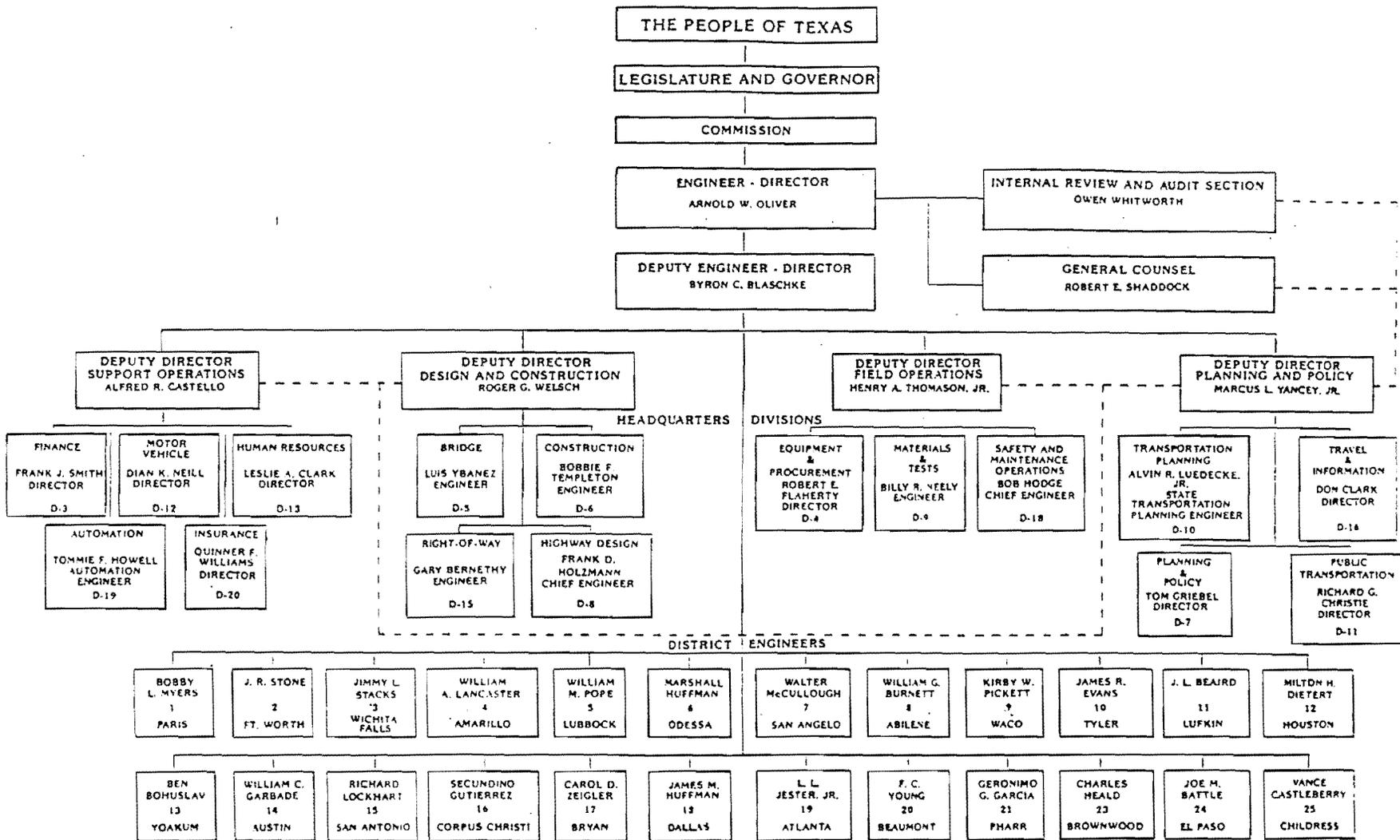


Figure 1. Organizational Structure of the Texas Department of Transportation (1989)

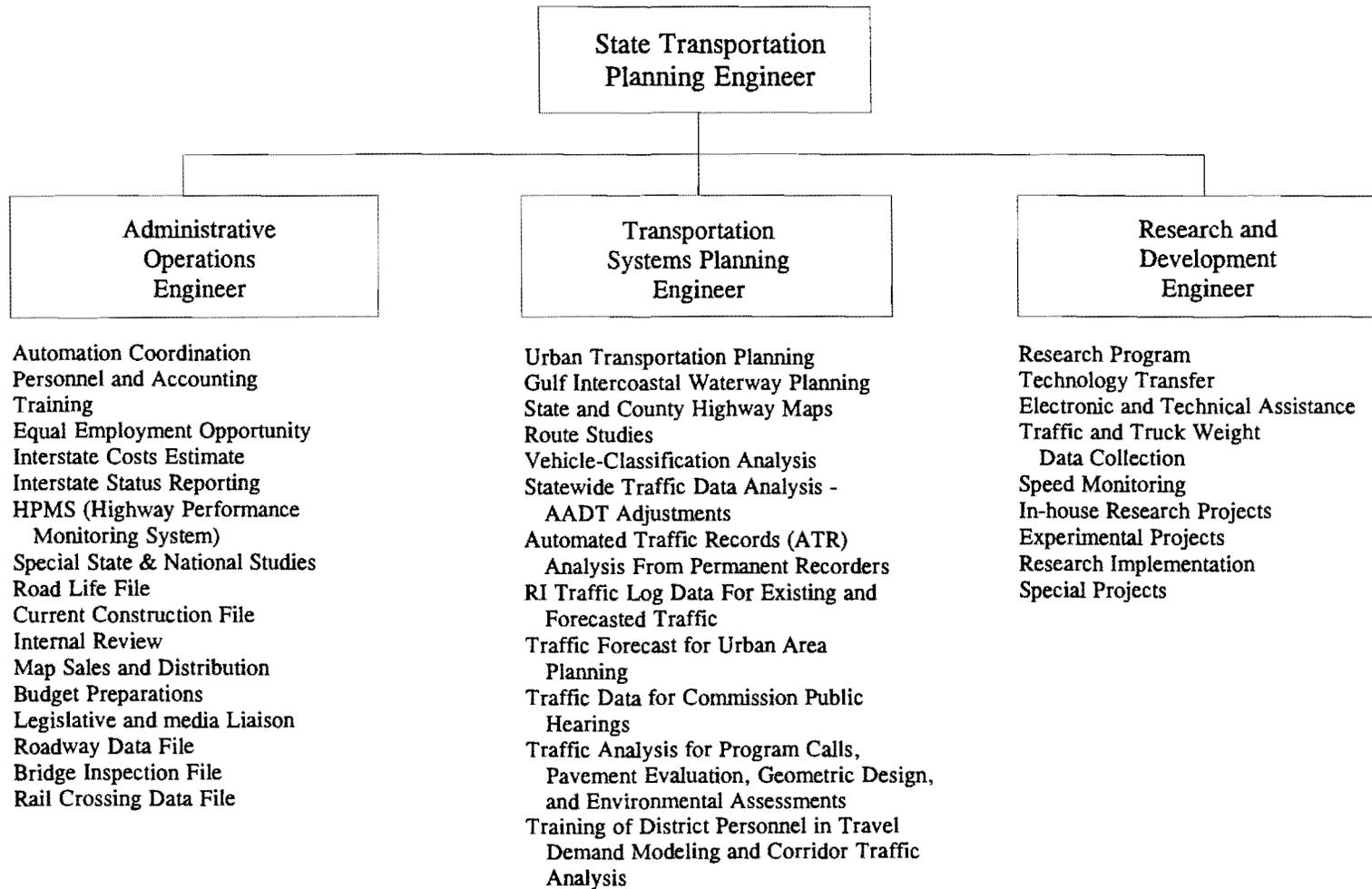
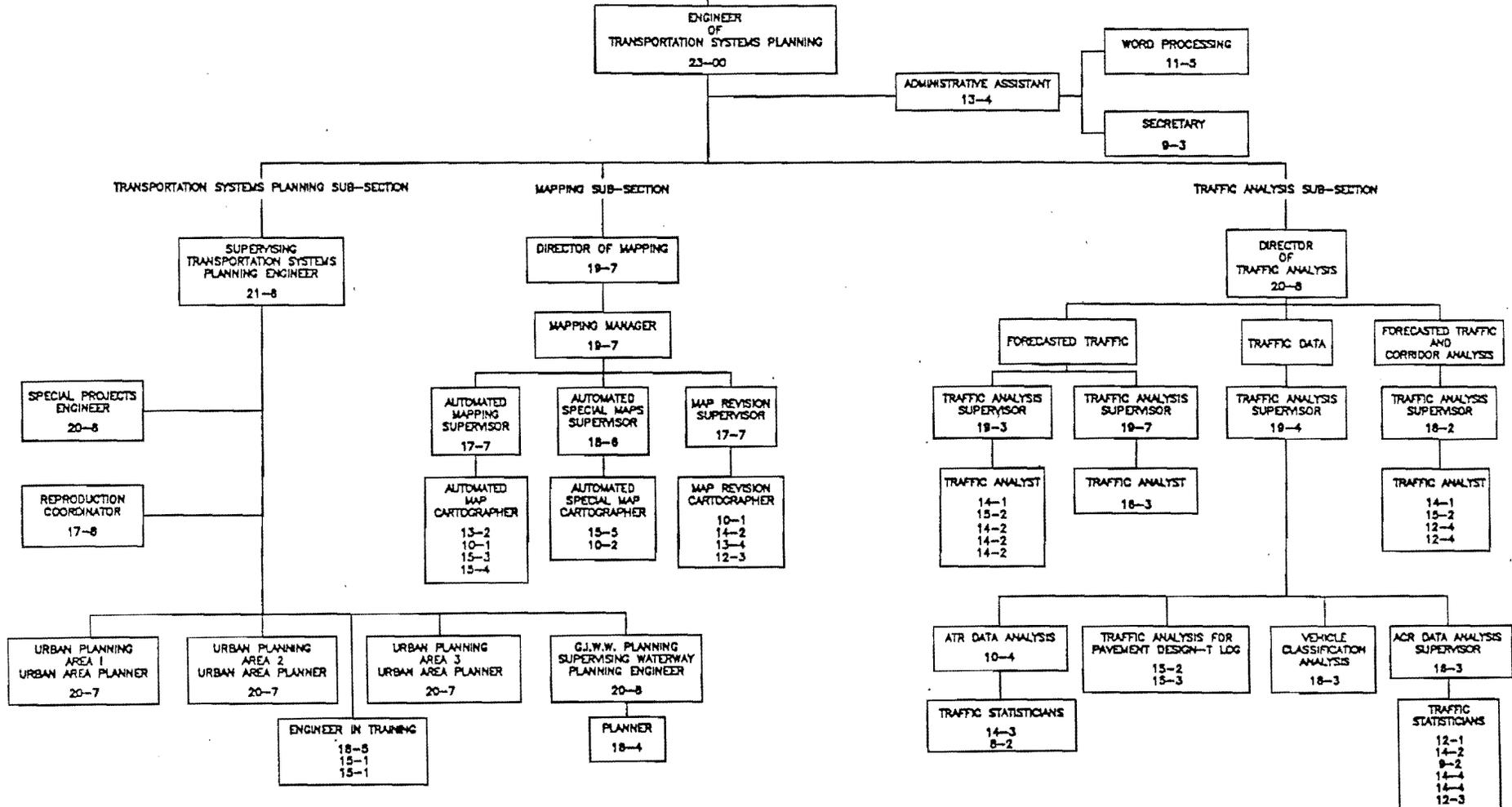


Figure 2. Organizational Structure and Responsibility of the Transportation Planning Division (1989)

TRANSPORTATION SYSTEMS PLANNING



NOTE: XX-X denotes salary group and step (see table 2).
 For example, the Systems Planning Subsection has three Engineers in training (salary groups 18-5, 15-1, 15-1).

Figure 3. Organizational Structure of the Transportation Systems Planning Section (1989)

The Traffic Analysis Subsection developed, implemented, and maintained the Department's traffic forecasting procedures and the basic traffic data needed to support these functions. The responsibility for developing and maintaining the socioeconomic and traffic network data needed in the traffic forecasting process was with the Department's District offices and the state's Metropolitan Planning Organizations (MPOs).

Staffing and Salary Levels

A detailed organizational chart and staffing plan for the 1989 Transportation Systems Planning Section is shown in Figure 3. This section consisted of a staff of 63 individuals, with approximately 50 percent of the staff assigned to the Traffic Analysis Subsection.

Table 1 summarizes 1989-1991 salary levels; Table 2 shows current salary levels. Table 3 lists typical duties and requirements for traffic forecasting/modeling positions within the Transportation Systems Planning Section. As shown in Table 1, 1989-1991 salaries for entry- to mid-level traffic modelers (Salary Groups 14 and 15) ranged from \$1975 to \$2400 per month; today the salary range is \$2095 to \$2816 per month. Staff in these two salary groups (i.e., 14 and 15) account for nearly one third of the Transportation Systems Planning Section's total staff.

Table 1
Representative Salary Levels, Transportation Systems Planning Section, TxDOT

Salary Group	Job Title	No. Employees in this Group	Monthly Rate ^a	
			Average	Range
12	Traffic Corridor Analyst I	5	\$1850	\$1731-1911
14	Traffic Corridor Analyst II/ Traffic Modeler I	10	\$2062	\$1975-2180
15	Traffic Modeler II	9	\$2220	\$2108-2403
17	Traffic Modeler III	3	\$2862	\$2730-3027
18	Corridor Analysis Supervisor	5	\$2933	\$2744-3127
19	Traffic Modeling Supervisor	5	\$3303	\$3027-3455
20	Traffic Analysis Manager	6	\$3694	\$3341-3814

^a Values shown for Average and Range are based on actual salaries as of September 1989
 Note that job titles did not necessarily match job duties: there are 37 positions with job titles indicating forecasting duties; but only 17 employees were doing forecasting, of which only seven were travel demand modelers..

Table 2
Representative Salary Levels, Transportation Analysis Branch, TxDOT

Salary Group	Job Title	No. Employees in this Group	Monthly Rate ^a	
			Average	Range
12	Traffic Corridor Analyst I/Cartographer II	2	\$1836	\$1836-2312
14	Traffic Corridor Analyst II/ Traffic Modeler I/Cartographer III	6	\$2095	\$2095-2638
15	Traffic Modeler II	3	\$2236	\$2236-2816
16	Traffic Modeler III	1	\$2389	\$2389-3009
18	Traffic Modeler Group Supervisor	1	\$2816	\$2816-3544
19	Traffic Modeling Supervisor	3	\$3212	\$3009-3785
21	Transportation Analysis branch Manager	1	\$3285	\$3430-4322

^a Values shown for Average and Range are based on actual salaries as of December 1992.
 Note again that although nine positions are job titles in modeling, only four employees were involved in full-time travel demand modeling.

**Table 3
Duties and Requirements for Selected TxDOT Traffic Forecasting Positions**

Salary Group	Job Title	Duties	Requirements
12	Traffic Corridor Analyst I	<ul style="list-style-type: none"> • Learns to prepare layouts of traffic corridors under study • Learns to apply modeled traffic data to corridor layout • Learns to adjust modeled data according to actual traffic counts • Learns to adjust modeled data for land use changes in the area of the study • Learns to prepare projections of future traffic densities based on known or projected growth rates • Learns to prepare final layouts and data tabulations for forwarding to district personnel 	Graduation from high school or equivalent plus four years progressive related work experience
14	Traffic Corridor Analyst II	<ul style="list-style-type: none"> • Prepares layouts of traffic corridors under study • Applies modeled traffic data to corridor layout • Adjusts modeled data according to actual traffic counts • Prepares projections of future traffic densities based on known or projected growth rates • Prepares final layouts and data tabulations for forwarding to district design personnel 	Graduation from high school or equivalent plus five years of progressive related work experience
14	Traffic Modeler I	<ul style="list-style-type: none"> • Learns systems and procedures used by the Department to model current and forecast traffic as required by federal law and Department policy • Learns to enter data into computer traffic or transit model via ROSCOE • Learns to run, calibrate, and validate Trip Generation Models • Learns to run, calibrate, and validate Trip Distribution Models • Learns to prepare presentations and handouts for governmental planning bodies • Learns to perform research necessary to acquire input data for modeling programs • Learns to run computer forecasts of traffic projections 	<p>A bachelor's degree from an accredited college or university in math, computer science, or related course of study plus two years of related work experience</p> <p>Experience in traffic data collection, traffic analysis, or related statistical studies may be substituted for college education requirement on a year for year basis</p>
15	Traffic Modeler II	<ul style="list-style-type: none"> • Uses systems and procedures of the Department to model current and forecast traffic as required by federal law and Department policy • Enters data into computer traffic or transit models via ROSCOE • Runs, calibrates, and validates Trip Generation Models • Runs, calibrates, and validates Trip Distribution Models • Runs, calibrates, and validates Trip Assignments • Prepares presentations and handouts for governmental planning bodies • Performs research necessary to acquire input data for modeling programs • Runs computer forecasts of traffic projections 	<p>A bachelor's degree from an accredited college or university in math, computer science, or related course of study plus two years of related work experience</p> <p>Experience in traffic data collection, traffic analysis, or related statistical studies may be substituted for college education requirement on a year for year basis</p>

Table 3
Duties and Requirements for Selected TxDOT Traffic Forecasting Positions (Cont.)

Salary Group	Job Title	Duties	Requirements
17	Traffic Modeler III	<ul style="list-style-type: none"> • Enters data into computer traffic or transit model via ROSCOE • Runs, calibrates, and validates Trip Generation Models • Runs, calibrates, and validates Trip Distribution Models • Runs, calibrates, and validates Trip Assignments • Prepares presentations and handouts for governmental planning bodies • Performs research necessary to acquire input data for modeling programs • Contacts district offices to obtain data for modeling purposes • Runs computer forecasts of traffic patterns and demands • Makes presentations of traffic and transit model data to governmental planning bodies • May perform liaison work with local, state, and federal agencies to obtain necessary data 	Graduation from a four-year college or university with a degree in mathematics, computer science, or related course work
18	Corridor Analysis Supervisor	<ul style="list-style-type: none"> • Supervises preparation of corridor traffic layouts which are used by design engineers to determine placement of on and off ramps, turn lane lengths, and general intersection design • Supervises preparation of truck traffic percentages and equivalents used in highway slab thickness determinations • Provides beginning and ending traffic estimates for 10-year Project Development Plan • Supervises installation and maintenance of the Traffic Log File • Provides on-going training for traffic analysts • Coordinates with districts and divisions regarding their requests for corridor analysis 	Graduation from a four-year college or university with a degree in a related field plus five years of progressive related work experience may be substituted for education in a year for year basis
19	Traffic Modeling Supervisor	<ul style="list-style-type: none"> • Calibrates and validates mathematical simulations (models) and uses same to project traffic data for future years • Spends 35% of time in managerial activities • Performs special statistical studies/analyses for entities outside of the Division such as the Attorney General's Office, the Highway Commission, and Districts and Divisions. Works with consultants, Councils of Government, and city planners • Makes presentations to planning groups, city planners, technical and political committees • Uses high level mathematics, i.e., integral calculus and time series 	Graduation from a four-year college or university with a degree in mathematics, computer science, or related field plus progressive extensive work experience that included supervisory responsibilities
20	Traffic Analysis Manager	<ul style="list-style-type: none"> • Spends 100% of time in managerial duties • Sets priorities for subordinate supervisors • Prepares budget for area of responsibility • Supervises traffic forecasting for 5-, 10-, and 20-year plans • Meets with city, county, Councils of Government, consultants, Federal Highway Administration and the State Department of Highways and Public Transportation personnel in regard to traffic analysis and planning • Conducts workshops and training seminars on traffic analysis and transportation planning 	Graduation from a four-year college or university with a degree in a related field plus extensive progressive work experience that included supervisory responsibilities

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Theoretically, salaries for Traffic Modeler III (Salary Group 17) were approximately \$2900/month although there were no active modelers above Group 15 except two Traffic Modeling Supervisors (Groups 18-20) who were in the \$2700/month to \$3800/month salary range. Supervisory/managerial positions (Groups 18-20) accounted for about 30 percent of the Transportation Systems Planning Section's total staff but only 21 percent of the Traffic Analysis Subsection's total staff.

The basic requirement for senior corridor analysis and traffic modeling positions was a "bachelor's degree in mathematics, computer science, or a related field" (Table 3). The Traffic Corridor Analyst positions (Groups 12 and 14) required only graduation from high school or equivalent and four to five years of related work experience. None of the positions required civil engineering or planning degrees, although some staff were pursuing a postgraduate degree in planning.

Discussion

According to Transportation Systems Planning Section management personnel, the primary advantage of the Section's organizational structure was the centralized nature of the Department's forecasting function. The result of this centralization, according to Transportation Systems Planning Section management, was a uniform and consistent traffic forecasting process. The centralization of the forecasting function, however, had a number of inherent disadvantages. For example, the structure in which all traffic forecasts were prepared by the Transportation Systems Planning Section resulted in a misperception in some districts of both a backlog of requests and a less than desirable turn-around time. As discussed in subsequent chapters of this report, the Section's turn-around time for traffic forecasts may have been related to both its TTI-supported repertoire of forecasting procedures and the high turnover among the limited number of traffic forecasters. However, the Transportation Systems Planning Section noted that frequently its turn-around time could have been improved if the Districts and MPOs were more responsive in providing the socioeconomic and network data needed to perform traffic assignments. Other problem areas identified by Section management included the need to improve land use and demographic monitoring and forecasting methods and the need to develop procedures to incorporate economic development impacts into the

transportation planning process.

In summary, the basic problems associated with the centralized nature of the Department's traffic forecasting function were in the area of communications with the Districts. For example, the Section noted that the Districts frequently requested too much detail at early stages of the planning/design process. There was concern that district personnel use appropriate levels of detail for forecasts at various stages of project planning and design. Also, the Transportation Systems Planning Section expressed concern that many Districts might misinterpret the highly technical forecasts. District personnel needed to be trained in the basics of travel demand modeling to ensure that the forecasts provided by the Transportation Systems Planning Section were interpreted and applied in an appropriate manner. For example, travel demand models provide a useful tool to examine forecasted traffic in urban area corridors; however, one link volume may not be indicative of the entire corridor of parallel network facilities. It requires intensive corridor analysis by an experienced traffic analyst who has worked with both trendline/linear regression and travel demand modeling techniques to successfully project traffic throughout the state in a uniform and consistent manner.

As an initial step in addressing these concerns, the Transportation Systems Planning Section suggested that each District designate an individual to serve as liaison between the District and the Section. It also suggested that it would be helpful if requests for traffic forecasts from the Districts were ranked in order of priority.

MICHIGAN DEPARTMENT OF TRANSPORTATION

Organizational Structure

The organizational structure of the Michigan Department of Transportation (MDOT) is shown in Figure 4. As a Department of Transportation (as opposed to a Department of Highways, for example), MDOT's organizational structure reflects its multimodal responsibilities (e.g., aeronautics, highways, and urban and intercity transit). The major functional areas of MDOT's organizational structure, however, are not substantially different from those in the TxDOT structure.

The Bureau of Transportation Planning is responsible for MDOT's transportation planning functions (Figure 5). The Bureau of Transportation Planning's role is to develop and implement an

ongoing transportation planning process which results in recommendations for programming transportation improvement projects. The Bureau of Transportation Planning consists of four divisions: the Program Planning Division, the Project and Plan Development Division, the System Planning Division, and the Transportation Planning Services Division.

The goal of the Program Planning Division is to provide a resource allocation perspective within the Department to ensure that capital investment is guided by specific objectives and long-term goals. The Program Planning Division develops the long-range investment plans and long-range program for the Department, conducts comprehensive planning activities, takes part in the annual selection of highway projects, and reports the annual multimodal transportation program to the legislature.

The Project and Plan Development Division is responsible for conducting a planning process which results in urbanized area and regional transportation plans.

The Systems Planning Division develops and maintains a continuing statewide systems planning process for highway facilities, passenger systems, and freight services, including the conduct of analyses or plans resulting in recommendations for state-level projects and programs and the assessment of needs for all modes.

The Transportation Planning Services Division develops and maintains a process which provides social, economic, and environmental inventories and impact analyses; operates a public involvement program under the procedures required by state and federal involvement/public hearing procedures; assesses social, economic, and environmental impact issues; develops mitigation proposals and monitors mitigation implementation; conducts transportation surveys; and manages and reports data relating to the transportation system.

The primary responsibility for traffic forecasting rests with the Demand Estimation and Travel Impact Analysis Section of the Project and Plan Development Division (Figure 5). However, this responsibility is shared in various degrees with other sections within the Bureau of Transportation Planning.

The Demand Estimation Section is responsible for developing, maintaining, and implementing the travel demand modeling procedures for the state's 3-C, statewide, small urban area, and rural planning processes. In most aspects, the process is similar to the centralized approach

employed in Texas. The 3-C travel demand modeling process is conducted by the Demand Estimation Section using “standard” four-step mainframe models for 13 of the state’s 14 urbanized areas (travel demand modeling for the Detroit area is the responsibility of the MPO). The responsibility for developing and maintaining the current and forecast socioeconomic data needed for traffic forecasting rests with the state’s MPOs.

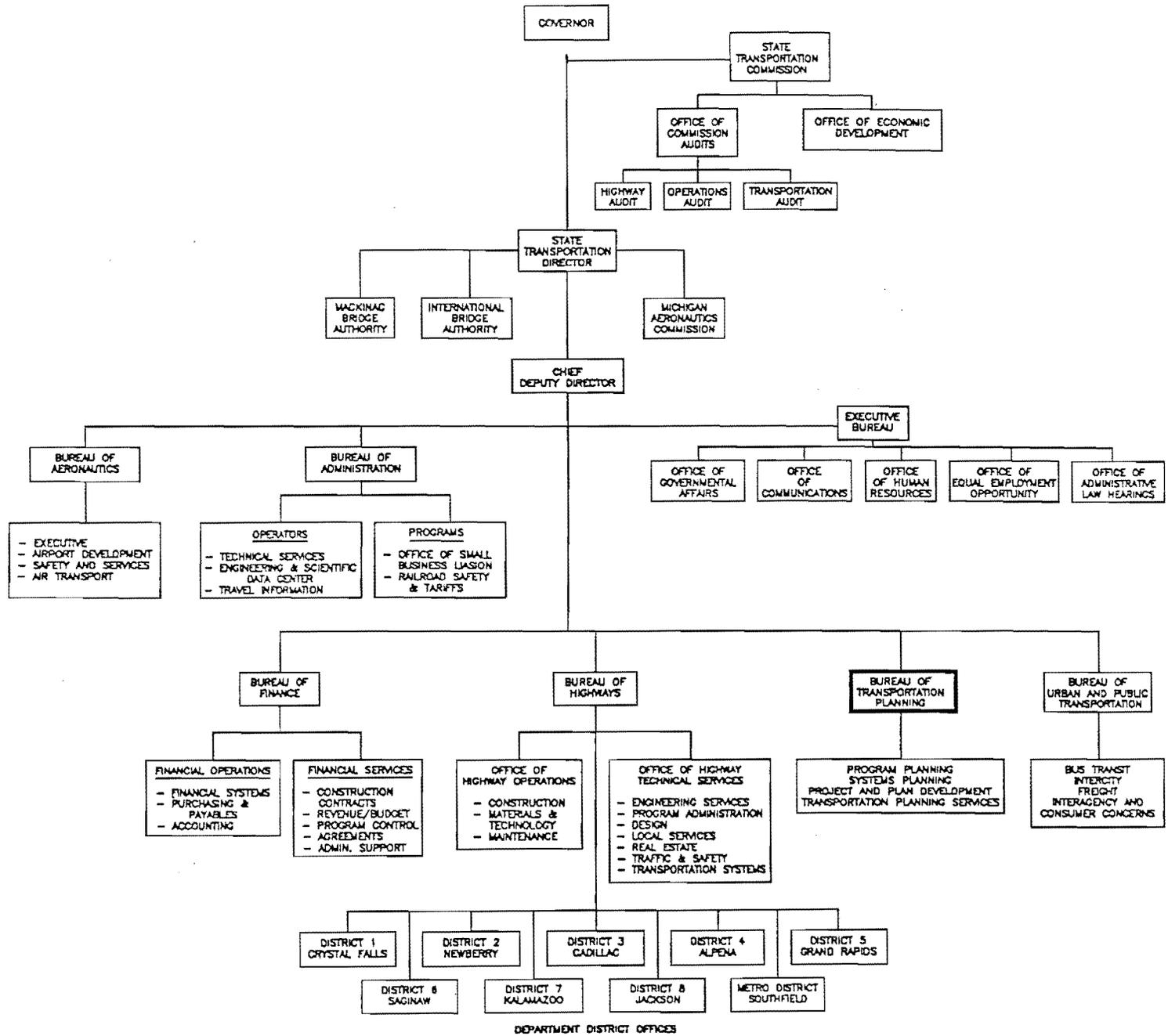


Figure 4. Organizational Structure of the Michigan Department of Transportation

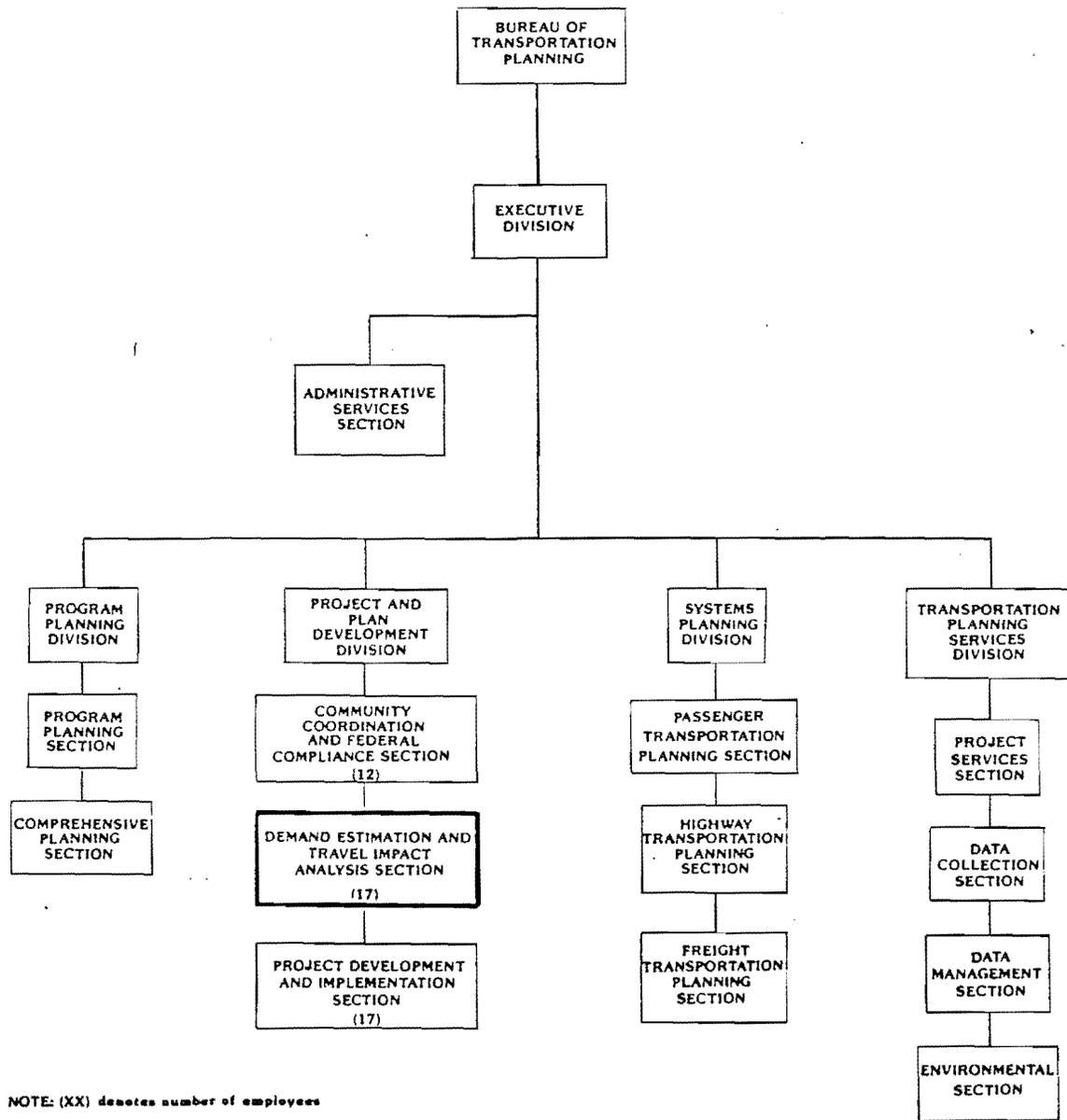


Figure 5. Organizational Structure of MDOT's Bureau of Transportation Planning

Staffing and Salary Levels

The Project and Plan Development Division of the MDOT Bureau of Transportation Planning employs a total of 46 individuals (including clerical and support personnel). The staffing levels of individual sections of the Project and Plan Development Division are listed below:

<u>Section</u>	<u>No. of Employees</u>
Community Coordination	12
Demand Estimation	17
Project Development	<u>17</u>
TOTAL	46

The staffing level of the Demand Estimation Section of MDOT (17 employees) is about two and one-half times the level of TxDOT's seven modelers in the Traffic Analysis Subsection involved in modeling. TxDOT staff was responsible for preparing travel demand model traffic forecasts for about twice the number of urban areas, 24 for TxDOT versus 13 for MDOT. TxDOT traffic forecasting staff (17 employees: seven modelers and nine trendline/regression forecasters) was responsible for three times as many districts as their Michigan counterparts, 25 districts in Texas versus eight in Michigan. Moreover, while the Demand Estimation Section of MDOT is responsible for preparing system-level forecasts of rural traffic, the Project Development and Implementation Section (17 employees) was responsible for preparing project-level forecasts of traffic on Michigan's rural highways. Based on these considerations along with the fact that other MDOT divisions (e.g., the Systems Planning Division) develop various "special purpose" traffic forecasts, it appears that the relationship between staff levels and work loads are substantially different between the two states. The ratio of MDOT to TxDOT staff involved in both model and trendline/linear regression forecasting is a little more than two and one-half to one (46 to 17 employees).

Table 4 presents a comparison of salary levels for selected traffic forecasting positions in Michigan and Texas. The limited data in Table 4 suggest that entry level salaries in Michigan and Texas are comparable. For the mid- and upper-level positions, MDOT salaries are roughly 20 percent higher than for comparable positions at TxDOT. The comparison of salary rates, however, does not consider employee benefits and cost-of-living differentials between the two states. The absence of

state and local income taxes in Texas, for example, should be considered in comparing salary rates in other states. Nevertheless, the TxDOT forecasting staff was and remains substantially smaller than at MDOT.

Discussion

According to MDOT traffic forecasting management personnel, the principal advantage of their organizational structure is the uniformity and consistency of the forecasting process that results from the centralized nature of the forecasting function. Management personnel were also quick to point out the problems inherent in highly centralized organizational structures. The massive amounts of time, manpower, money, and data needed to maintain and implement traditional mainframe travel demand models for each of the state's urbanized areas can be overwhelming. The models must be kept current and, ideally, the models should be flexible enough to respond to a range of alternative design and network configurations in a timely fashion.

Table 4
Comparison of Salary Levels for Representative Traffic Forecasting Positions, MDOT and TxDOT

Job Title (MDOT)	Requirements	Comparable TxDOT Positions	Beginning Hourly Rate	
			MDOT	TxDOT
College Trainee IV (Entry level)	Bachelor's degree in urban or regional planning, engineering, resource development, statistics, mathematics, economics, geography, or related field	Traffic Modeler I (requires one year of experience)	\$10.90	\$11.41
Transportation Planner VII	Bachelor's degree in urban or regional planning, engineering, resource development, statistics, mathematics, economics, geography, or related field; three years experience in travel demand modeling	Traffic Modeler II (requires two years of experience)	\$14.79	\$12.18
		Traffic Modeler III (requires four years of experience)		\$13.89
Transportation Planner IX (Supervisor)	Bachelor's degree in urban or regional planning, engineering, resource development, statistics, mathematics, economics, geography, or related field; four years experience in travel demand modeling	Traffic Modeler III	\$16.81	\$13.89

While these problems are perhaps more technical than organizational in nature, management personnel at MDOT stressed the importance of an organizational structure which (1) fosters excellent communication between the forecasters/modelers and their clients (i.e., Districts and MPOs); and (2) clearly defines the roles and responsibilities of the actors in the process. Frequently the technical aspects of travel demand modeling can become so consuming that there is little, if any, time for documentation, communication, and constructive feedback.

As discussed earlier, the Demand Estimation and Travel Impact Analysis Section of the Bureau of Transportation Planning prepares the majority of MDOT's traffic forecasts. However, the Systems Planning Division (see Figure 5) also prepares traffic forecasts as part of its multimodal planning activities. In most cases, the Demand Estimation Section has been involved in developing the multimodal forecasts. This has not always been the case, however; and the roles of the Systems Planning and Project and Plan Development Divisions need to be clarified in preparing traffic forecasts. This clarification is needed to avoid duplication of effort and to ensure consistency in the forecasts.

NEW YORK STATE DEPARTMENT OF TRANSPORTATION

Organizational Structure

The organizational structure of the New York State Department of Transportation (NYSDOT) is shown in Figure 6. Responsibility for the state's transportation planning program is shared by the Planning and Research, Data Services, and Project Development Bureaus of the Office of Planning and Program Management. The Planning and Research Bureau is responsible for the basic administration of the department's long-range transportation planning program, providing regional planning and local government liaison functions for the development of long-range transportation plans, unified work programs, and transportation improvement programs.

The Project Development Bureau is responsible for short-term, project-level transportation planning, providing an interface between the planning and design functions. The Project Development Bureau reviews and approves traffic forecasts for roadway design and provides assistance in project-level planning studies (e.g., corridor/route studies).

The Forecasting Section of the Data Services Bureau has been given the responsibility of

coordinating the state's traffic forecasting activities. The Traffic Inventory and Highway Facilities Inventory Sections of the Data Services Bureau are responsible for the state's traffic data collection/analysis and highway inventory programs. The structure, staffing level, and general responsibilities of the Data Services Bureau are shown in Figure 7. Note that, unlike TxDOT and MDOT, the traffic forecasting and data collection functions are located in the same administrative unit (the Data Services Bureau).

The approach to traffic forecasting, and transportation planning in general, at the NYSDOT is substantially different than the approaches used in Texas and Michigan. In New York State, the state's 11 regional (district) offices and the state's 11 MPOs are responsible for preparing traffic forecasts and implementing the urban travel demand modeling process. The Data Services Bureau provides technical support, guidance, training, information sharing, and standards in the areas of travel surveys and traffic forecasting models and techniques. In addition, the Data Services Bureau reviews and approves all long-range forecasts; and the Project and Development Bureau reviews and approves all traffic data and forecasts prior to their use in project design.

In contrast to the highly centralized transportation planning and traffic forecasting structures of TxDOT and MDOT, NYSDOT has decentralized the process. Instead of focusing on the actual implementation of the state's traffic forecasting activities, the Traffic Forecasting Section of NYSDOT has concentrated on coordinating the forecasting efforts of the state's regional offices and MPOs and providing these agencies with the tools, training, and technical support needed to conduct the state's traffic forecasting functions in a timely and efficient manner.

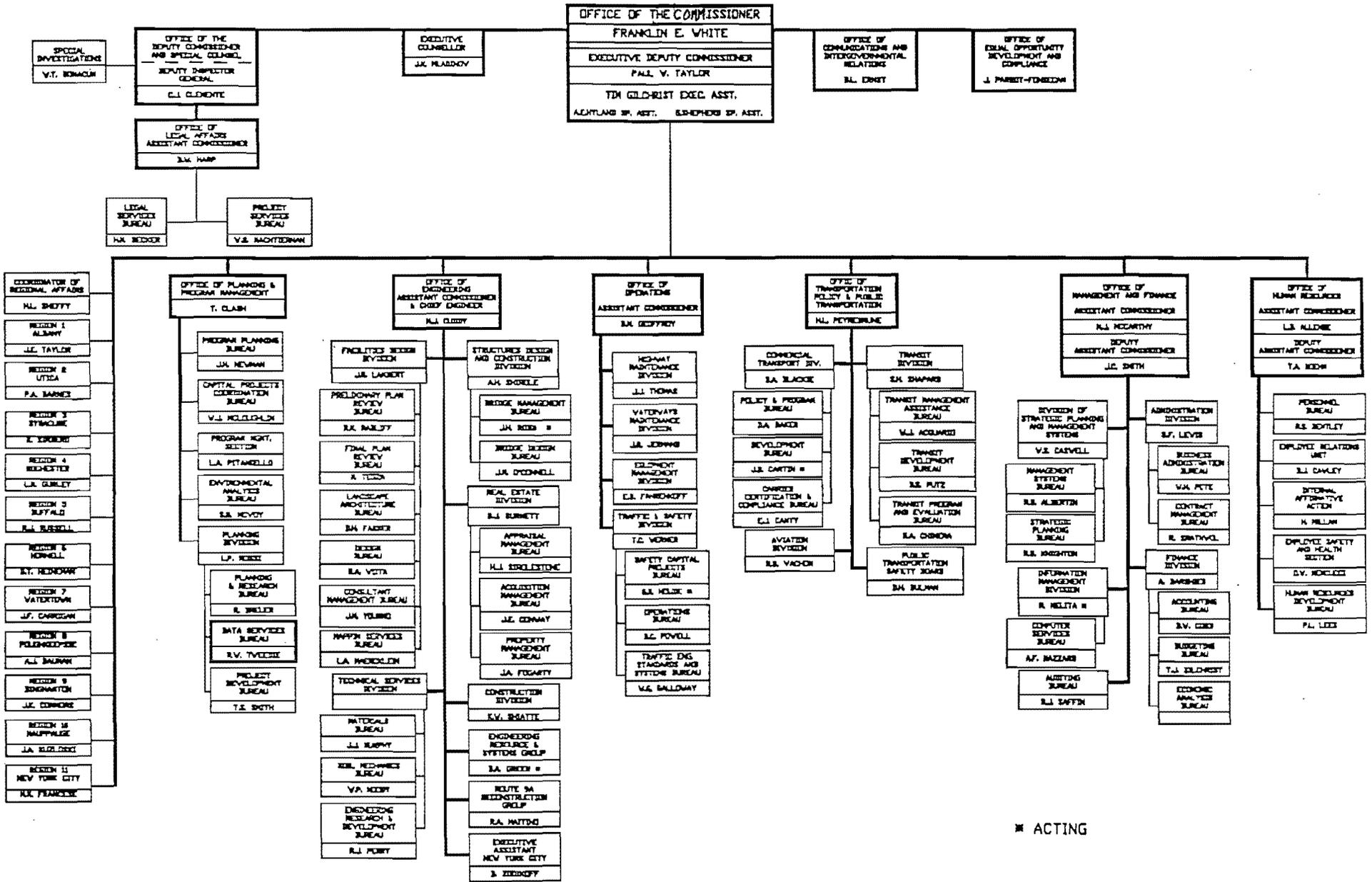
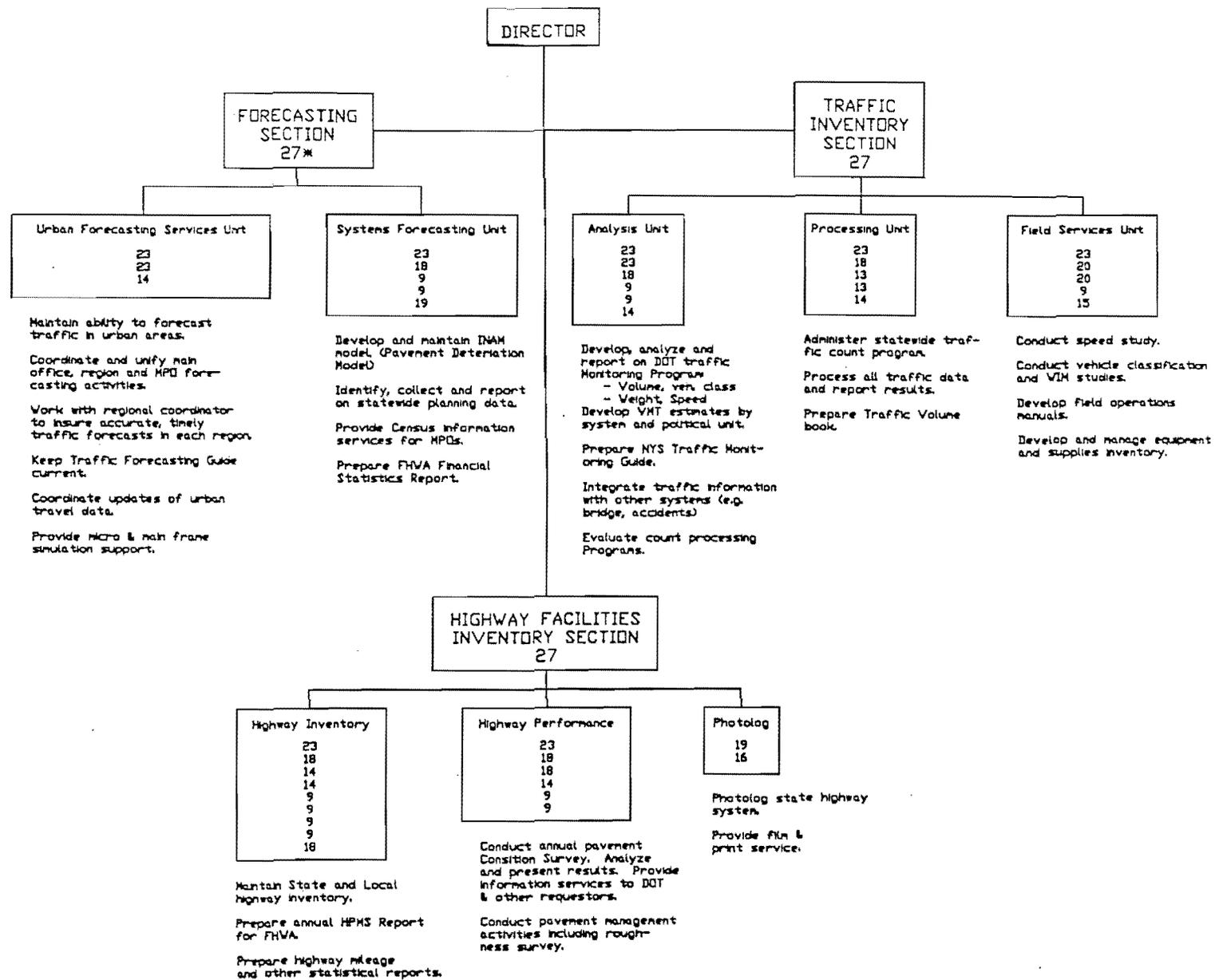


Figure 6. New York State Department of Transportation Organizational Structure

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* - Denotes employee salary grade. For example, the Traffic Forecasting Section Manager is salary grade 27. The Urban Forecasting Services Unit has a staff of three (salary grades 23, 23 and 14).

Figure 7. Data Services Bureau of NYSDOT

Staffing and Salary Levels

The Data Services Bureau has a total of 47 employees (Table 5). The Traffic Forecasting Section of the Data Services Bureau is responsible for providing technical assistance in developing, implementing, and monitoring the state's forecasting procedures and has only nine employees (see Figure 7). Two other NYSDOT bureaus, the Planning and Research and the Project Development Bureaus, also have responsibilities in the transportation planning area. The Planning and Research Bureau, with a staff of 44 individuals, is responsible for the overall administration of the state's long-range transportation planning program. The Project Development Bureau is responsible for reviewing and coordinating short-term, project-level transportation planning activities and employs 32 individuals (Table 5).

The organizational structure and philosophy of the NYSDOT prevents a direct, one-to-one comparison with TxDOT in terms of staffing and salary levels. However, if staff for those functions and sections of the NYSDOT which do not have counterparts at the Transportation Systems Planning Section of TxDOT are removed from consideration, a general comparison can be made. For example, if the Traffic and Highway Inventory staff (Data Services Bureau), Policy and Systems Planning staff (Planning and Research Bureau) and the Economic Analysis staff (Project Development Bureau) are removed from the staffing plan outlined in Table 5, the resulting staff level of 68 individuals is comparable to the Transportation Systems Planning Section's staffing level of 63 individuals. This should be viewed as a coarse comparison for the following reasons: (1) nearly one-fourth of the NYSDOT staff in Table 5 is assigned specifically to the New York City Region (suggesting that, relative to TxDOT, the NYSDOT staffing level may be somewhat inflated); and (2) the Transportation Systems Planning Section at TxDOT is responsible for 24 MPOs and 25 highway districts while NYSDOT staff are responsible for 11 MPOs but only 11 districts (suggesting that NYSDOT staffing levels should be lower than at TxDOT). In terms of staffing levels for traffic data analysis and forecasting, the Traffic Analysis Subsection of the Transportation Systems Planning Section employs 29 individuals (see Figure 3).

Table 5
Staffing Levels for NYSDOT Bureaus with Traffic Forecasting and
Transportation Planning Responsibilities

Bureau and Section	No. of Employees
Data Services	
Director's Office	3
Forecasting Section	9
Traffic Inventory Section	17
Highway Inventory Section	<u>18</u>
TOTAL	47
Planning and Research	
Director's Office	3
Downstate ^a Planning Section	12
Upstate ^b Planning Section	16
Policy and Systems Planning Section	<u>13</u>
TOTAL	44
Project Development	
Director's Office	2
Economic Analysis and Industrial Access	7
Sections	
Downstate ^a Project Section	16
Upstate ^b Project Section	<u>7</u>
TOTAL	32

^a The Downstate Regions (Districts) are those in the New York Metropolitan Transportation Area (Regions 8, 10, and 11).

^b Regions (Districts) 1-7, and 9

Staffing for traffic forecasting and data analysis at NYSDOT consists of 38 individuals, as summarized below. This staffing level is two and one-half times higher than at TxDOT. As noted in the discussion of staffing levels for general transportation planning functions, the relatively large number of staff assigned to project-level forecasting support for the New York City area (Downstate Project Section) should be considered in comparing the staffing levels of NYSDOT and TxDOT.

<u>Traffic Analysis/Forecasting Unit</u>	<u>No. of Employees</u>
Forecasting Section (Data Services Bureau)	9
Analysis Unit, Traffic Inventory Section (Data Services Bureau)	6
Downstate Project Section (Project Development Bureau)	16
Upstate Project Section (Project Development Bureau)	<u>7</u>
TOTAL	38

The transportation planning positions at NYSDOT are civil service positions, and promotion is based on completion of specified times of service (employment) in each salary grade and a competitive promotion examination schedule. Table 6 presents a comparison of salary levels for representative positions at NYSDOT and TxDOT.

The comparison shown in Table 6 is based on the relative locations of staff positions within the respective agency's organizational structure. For example, at NYSDOT positions immediately below Bureau Directors are filled by individuals at the G-27 salary level (see Figure 7). At the Transportation Systems Planning Section of TxDOT, these positions are typically filled by staff in salary groups 19 and 20 (see Figure 3). The general comparison in Table 6, then, is based on comparable levels of responsibility.

While it is difficult to make a direct one-to-one comparison of salary levels at NYSDOT and TxDOT, it appears that, in general, salary rates for managerial and supervisory positions at NYSDOT are substantially higher than for comparable positions at TxDOT. The comparison of

salary rates, however, does not consider employee benefits and cost-of-living differentials between the two states. The absence of state and local income taxes in Texas, for example, should be considered in comparing salary rates in other states. In conjunction with the higher salaries, the educational requirements for management level positions (Transportation Analyst Series) at NYSDOT encourage graduate-level course work with an emphasis in transportation.

Discussion

Management personnel at NYSDOT identified two basic benefits of their organizational structure/philosophy. First, by placing the primary responsibility for the actual implementation of the forecasting and modeling functions at the local/regional level, the headquarters staff can focus on the development of “procedures and methodologies.” Decentralizing the responsibility for implementing forecasting activities and centralizing the responsibility for the development of forecasting “tools”, according to NYSDOT, has resulted in the development of a much broader repertoire of forecasting procedures and models than is typically available at other state DOTs.

The second benefit of the NYSDOT approach is the “local control” of most of the basic aspects of the planning and modeling processes. Though the NYSDOT provides a “toolbox” of standard procedures and oversees local planning and forecasting activities, the approach, according to NYSDOT, still allows considerable flexibility in terms of developing programs which are responsive to local needs and conditions.

The NYSDOT personnel identified several disadvantages of their organizational structure. The basic problems enumerated by NYSDOT staff are in the area of communications. As noted earlier, the Data Services Bureau provides technical support, training, and standards for forecasting models and techniques. NYSDOT’s responsibilities in the area of training are particularly noteworthy. Due to relatively high staff turnover rates, particularly at the MPOs, and to reduce the potentials for “black box” applications of the forecasting procedures, NYSDOT staff must devote a substantial amount of time to ongoing training programs.

NYSDOT staff stressed the need to clearly define the roles and responsibilities of the actors in the planning process. The need for complete, concise, user-friendly documentation of forecasting procedures was also stressed by NYSDOT as a vital element in a good traffic forecasting program.

Table 6
Comparison of Salary Levels for Representative Traffic Forecasting and Transportation Planning Positions
NYSDOT and TxDOT

Job Title and Salary Grade (NYSDOT)	Comparable TxDOT Position(s)	Monthly Salary		Comments
		NYSDOT	TxDOT	
Transportation Planning Aide II (G-9)	Traffic Corridor Analyst I (G-12)	\$1535-1978	\$1731-1911	
Transportation Analyst (G-18) ^a	Traffic Modeler I (G-14)	\$2555-3180	\$1975-2180	Senior line staff at TxDOT and NYSDOT
	Traffic Modeler II (G-15)		\$2108-2403	
Senior Transportation Analyst (G-23) ^b	Corridor Analysis Supervisor (G-18)	\$3320-4089	\$2744-3127	Subsection Supervisors at TxDOT and NYSDOT
	Traffic Modeling Supervisor (G-19)		\$3027-3455	Unit Supervisors at NYSDOT
Associate Transportation Analyst (G-27) ^c	Traffic Modeling Supervisor (G-19)	\$4106-5018	\$3027-3455	Subsection Directors at TxDOT
	Traffic Analysis Manager (G-20)		\$3341-3814	Section Managers at NYSDOT

^a Master's degree or 30 graduate semester credit hours (civil engineering, mathematics, urban or regional planning, or related fields) or a bachelor's degree (in areas outlined above) and one year's experience (at level of professional responsibility) or six years experience at a level of professional responsibility.

^b Same as G-18 plus one year qualifying experience at G-18 or above.

^c Same as G-23 plus one year qualifying experience at G-23 or above.

While NYSDOT staff felt it was doing an excellent job in training and documenting forecasting methods, the staff felt a pressing need to develop, adopt, and communicate statewide standards concerning many of the basic elements of the traffic forecasting process. In this regard, NYSDOT is presently drafting guidelines and standards in the following areas. It is the intent of NYSDOT to incorporate these standards into the transportation planning Memoranda of Understanding with the state's MPOs:

- (1) Level of detail for traffic forecasts (systems-level versus corridor-level, total vehicle forecasts versus mode-specific forecasts, etc.);
- (2) Design year (establishment of a uniform planning horizon for all traffic forecasts);
- (3) Network detail (establishment of a standard, minimum level of detail);
- (4) Population/sociodemographic forecasts (standardization of procedures and data sources); and
- (5) Technical quality control (establishment of procedures and measures of effectiveness for use in assessing the accuracy/quality of traffic forecasts, forecasting procedures, and data collection efforts).

Though not strictly an organizational problem, NYSDOT staff mentioned the difficulty of maintaining (and in some instances, the complete lack of) a quality data base for traffic forecasting and general transportation planning. This appears to be a problem shared by most traffic forecasting agencies.

WISCONSIN DEPARTMENT OF TRANSPORTATION

Organizational Structure

The basic structure of the Wisconsin Department of Transportation (WIDOT) is shown in Figure 8. The Division of Planning and Budget (Figure 9) is the primary planning and budget administration unit for WIDOT. The Division of Planning and Budget was established to prepare all-mode transportation policy plans and policy analyses, to prepare long-range interrelated systems plans for the various transportation modes, to provide guidance in the preparation of multiyear transportation investment programs, to guide and coordinate Departmental budget proposals, to make program and management analyses, to make financial forecasts and revenue estimates, to make

transportation demand forecasts, and to provide a variety of planning and budget support services.

The Bureau of System Planning was established within the Division of Planning and Budget and consists of the following sections (Figure 9):

Transportation Forecasts and Analysis Section. This section is responsible for developing forecasts of future travel demand for all transportation modes, for assisting MPOs in developing comprehensive transportation plans in urban areas, for developing transportation planning methods and techniques, and for analyzing and documenting other transportation-related special studies. Specifically, the Transportation Forecasts and Analysis Section provides the following services:

- (1) Technical assistance and systemwide long-range transportation demand forecasts to local planning officials in the development of urban and regional transportation plans. WIDOT provides these forecasts for ten of the state's 11 MPOs. The Southeastern Regional Planning Commission develops travel demand forecasts for the Milwaukee Metropolitan area.
- (2) Travel demand forecasts for highway facilities in the state as required for system planning, geometric and structural design, and noise and air quality analysis.
- (3) Travel demand forecasts required for system planning for all transportation modes (air, rail, bus, autos, and trucks).
- (4) Estimates of system characteristics, such as annual vehicle miles traveled on state highway systems.
- (5) Recommendation and completion of special transportation studies.
- (6) Technical support and consultations on transportation-related issues to other sections and bureaus within the Department and to other state agencies.
- (7) Research into and development of new or improved transportation forecasting methodologies and techniques in anticipation of evolving planning needs of the Department.

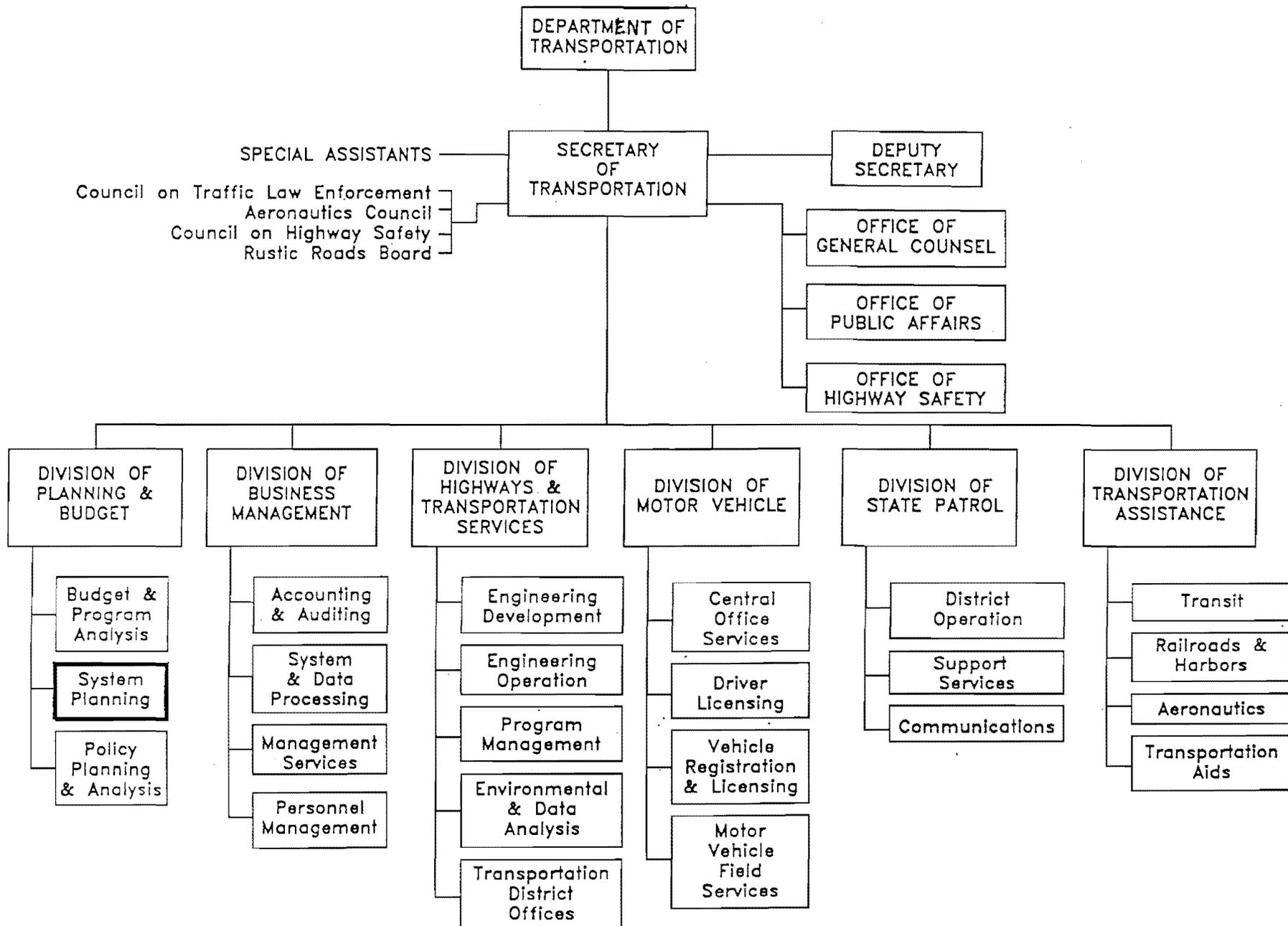


Figure 8. Organizational Structure of the Wisconsin Department of Transportation

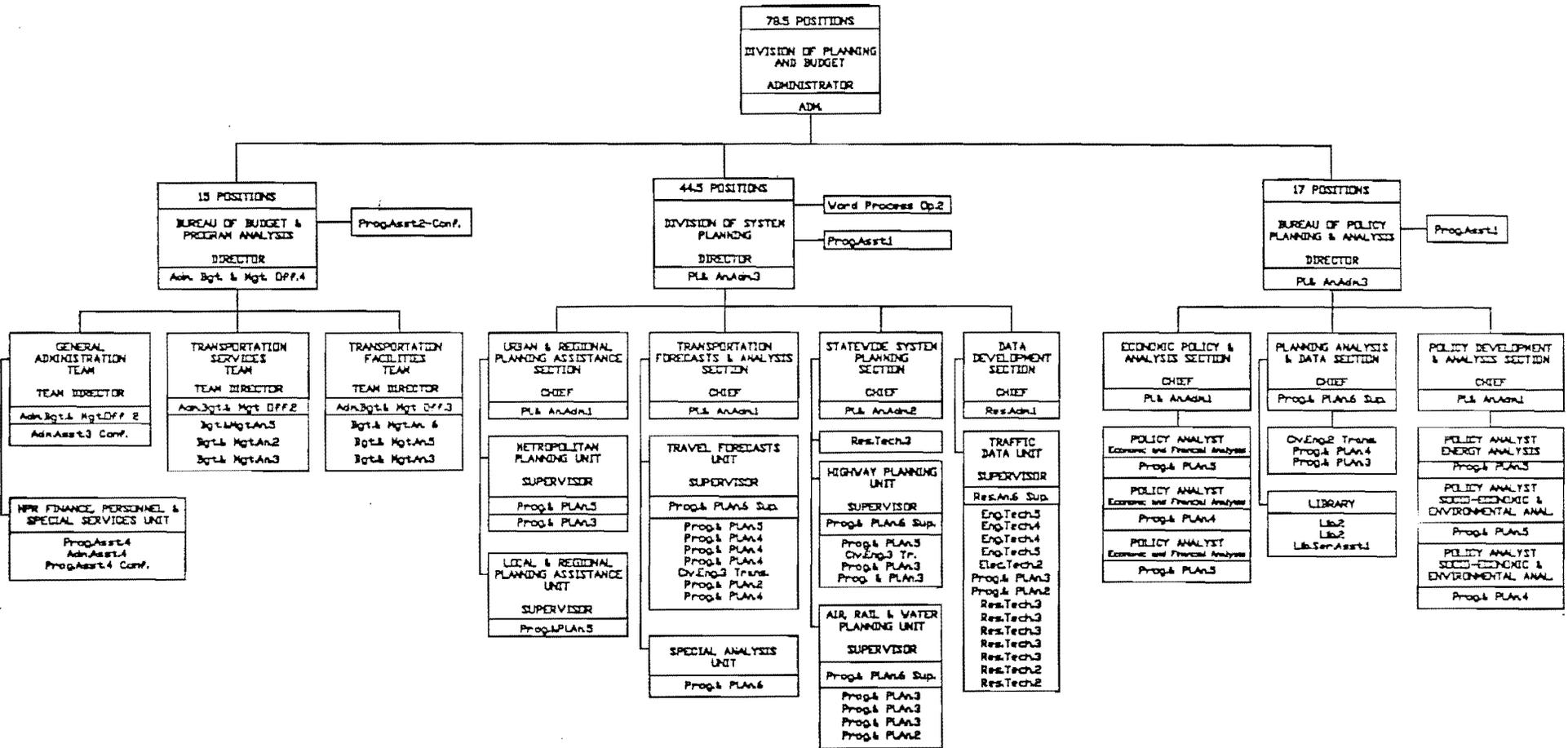


Figure 9. Organizational Chart, Division of Planning and Budget, WIDOT

Urban and Regional Planning Assistance Section. This section manages the Department's urban and regional planning assistance programs.

Statewide System Planning Section. This section prepares statewide system transportation plans and provides guidance concerning functional classification of highways, system planning, highway level-of-service studies, and general site or corridor planning.

Data Development Section. The Data Development Section provides the following services:

- (1) Conducts evaluations of transportation facility-use monitoring programs, policies, and operating procedures and implements new concepts for improved efficiency and effectiveness.
- (2) Plans and manages the Department's traffic data system of volume counts (automatic traffic recorder, control, seasonal, coverage, and special), vehicle speed and classification, and truck weights and characteristics in cooperation with other divisions.
- (3) Coordinates, designs, and directs/assists other sections/divisions and regional/local transportation planning agencies in the development and operations of travel habit/characteristics studies.
- (4) Reviews and conducts special traffic operational studies related to highway planning, design, and traffic engineering principles.
- (5) Prepares temporal adjustment factors and coordinates their application to ensure reporting compatibility.
- (6) Compiles, evaluates and prepares transportation facility use and travel-related estimates and summaries required for policy analysis, system planning and facility development, and design and operation.
- (7) Provides functional guidance, training, and support services in the procurement, maintenance, and repair of transportation data acquisition equipment.
- (8) Provides technical assistance and advice on transportation use matters to other sections, bureaus, and divisions, and other state departments of transportation.

Staffing and Salary Levels

The WIDOT Bureau of System Planning has a total of 43 employees distributed among its four sections as shown below:

<u>Section</u>	<u>Number of Employees</u>
Urban and Regional Planning Assistance	4
Transportation Forecasts and Analysis	11
Statewide System Planning	12
Data Development	<u>16</u>
	43

TxDOT's Transportation Systems Planning Section was comprised of 63 employees, 29 of which were assigned to the Traffic Analysis Subsection. Within the Traffic Analysis Subsection, staff were evenly distributed between travel demand modeling (seven); corridor analysis (nine) utilizing trendline/linear regression forecasting; and traffic monitoring (10). At WIDOT, forecasting and data analysis are assigned to two separate sections (Forecasts and Analysis and Data Development). Additionally, the section has a Mapping Subsection with 15 employees. The WIDOT Bureau of System Planning does not have a comparable unit. Based on these considerations, the total staffing level of WIDOT (Bureau of System Planning) and TxDOT (the Transportation Systems Planning Section) are comparable. However, at WIDOT forecasting staffing levels are more than twice as high as at TxDOT (15 to seven employees). Also, WIDOT staff are responsible for fewer districts than the Transportation Systems Planning Section (eight in Wisconsin, 25 in Texas), although this may be offset by WIDOT's multimodal forecasting responsibilities.

Table 7 presents a comparison of salary rates at WIDOT and TxDOT. The comparison suggests that salaries for WIDOT positions are typically on the order of 20 percent higher than for positions with comparable responsibilities at TxDOT. The comparison of salary rates, however, does not consider employee benefits and cost-of-living differentials between the two states. The absence of state and local income taxes in Texas, for example, should be considered in comparing salary rates in other states.

Table 7
Comparison of Salary Levels for Representative Traffic Forecasting Positions
WIDOT and TxDOT

Job Title	Comparable TxDOT Position	Hourly Rate	
		WIDOT	TxDOT
Planning and Analysis Administrator 1 (Section Chief)	Traffic Analysis Manager	\$20.56-27.40	\$17.49-22.04
Program and Planning Analyst 6 (Unit Supervisor)	Traffic Modeling Supervisor	\$16.28-23.66	\$16.39-20.62
Program and Planning Analyst 5	Traffic Modeler III	\$15.11-21.83	\$13.89-17.49
Program and Planning Analyst 4	Traffic Modeler II	\$14.04-20.13	\$12.18-15.34
Program and Planning Analyst 3	Traffic Modeler I	\$13.05-18.58	\$11.41-14.36

Discussion

The basic strengths and weaknesses identified by WIDOT staff concerning organizational structure are similar to those in the other states interviewed. For example, WIDOT staff felt that centralizing the forecasting function was necessary to ensure consistency and uniformity in traffic forecasts and forecasting procedures. The staff pointed out, however, that given staffing levels and limited funds, the questions of whether centralizing the forecasting function has actually ensured the objectivity of the process and whether alternative organizational structures could improve the efficiency of the process have not been evaluated.

Like other state DOTs, WIDOT staff expressed the need to upgrade the data collection efforts associated with travel demand modeling. Given the fact that the financial resources needed to substantially upgrade the state's data collection efforts are not likely to become available in the near future, WIDOT staff expressed the need to develop forecasting tools that require less data (or less detailed data) than the current generation of mainframe models. Unfortunately, the current work load leaves little time to pursue the development of these forecasting tools. WIDOT staff stated that creation of a special studies unit whose responsibilities would include developing traffic forecasting guide, training, and general technology transfer functions would be helpful.

WIDOT staff also said that communications need to be improved among the participants in the forecasting process. The district offices in Wisconsin typically hire consultants to identify alternative highway improvements. These alternatives are then forwarded to the Forecasting Section for traffic demand analyses. Staff within the WIDOT Forecasting Section felt that, frequently, they were asked to analyze “too many alternatives.” According to the forecasting staff, it would be very helpful if an initial screening of these alternatives could be conducted at the district level. While this screening could reduce the number of alternatives, the WIDOT forecasters noted that, at this time, district staffs lack the knowledge and the tools to conduct the analyses.

SUMMARY

This chapter has presented a review of organizational structures for traffic forecasting at TxDOT and three other state DOTs. The review suggests that state DOT organizational structures, responsibilities, staffing and salary levels, and basic concerns are quite similar in the area of traffic forecasting. The differences between states are largely functional and administrative rather than technical in nature. In short, the other states interviewed are facing many of the same problems as TxDOT.

The prevailing opinion among the individuals interviewed in this phase of the study is that while organizational arrangements which foster improved communications and technology transfer are needed, any lasting and substantial improvements in traffic forecasting are going to come in part from expanding the range of forecasting tools available, developing and disseminating user manuals/guides for these tools, and increasing the quantity and quality of the data needed to support these tools. This review of practices suggests the following two basic organizational strategies for bringing about these improvements: (1) expand the responsibilities of the central (headquarters) forecasting unit to include development of new or improved traffic forecasting methodologies and the associated data collection efforts; or (2) transfer more of the responsibility for preparing traffic forecasts to local agencies (districts, MPOs) than is currently done, thereby freeing headquarters staff to concentrate on developing forecasting methodologies. Either approach is likely to require additional staff. Increasing the responsibilities of the central forecasting unit would very likely require additional headquarters staff if only to bring TxDOT staffing levels in forecasting into line

with national norms. Decentralizing the forecasting function would probably require an increase in local (district) staffs as well. With regard to expanding the responsibilities of the Traffic Analysis Subsection of the Transportation Systems Planning Section, the Department should consider creating a Traffic Forecasting Methods Unit and a Traffic Forecasting Data Unit.

In addition to the general recommendations outlined above, the results of this review suggested that TxDOT should formally designate a Statewide Planning Unit. The statewide planning unit should be in the Transportation Systems Planning Subsection based on the 1989-91 structure of the section.

CHAPTER 3

TxDOT TRAFFIC DATA COLLECTION AND ANALYSIS

GENERAL

TxDOT maintains an extensive traffic data collection program to support traffic forecasting, estimation of traffic volumes for use in facility design and other state, local, and national policy and administrative functions. There is a perception, however, that this program could be strengthened through improved statistical design of traffic data collection procedures, and that traffic data collection resources could be better balanced. Additionally, greater cooperation and coordination in data collection methods and use are becoming increasingly important. Concerns have been expressed about the analysis of these traffic data in facility design, environmental assessment, and urban travel demand modeling.

This chapter summarizes traffic data collection and analysis in Texas. The review focuses on the types of data collected, data collection and analysis methods, quality control procedures, and mechanisms for coordinating traffic data collection and analysis efforts.

TxDOT PRACTICES

Data Collection

The Research and Development Section of the Transportation Planning Division had responsibility for the Department's traffic data collection program. The Technical Services Subsection of the Research and Development Section collected traffic data throughout the state, though the Districts occasionally collected traffic data for limited, special purpose studies.

The Technical Services Subsection of the Research and Development Section collected traffic volume, speed, truck-weight, and pavement data to support traffic forecasting and to meet various state and federal policy and administrative requirements. A summary of the Research and Development Section's data collection programs is presented below.

Traffic Volume Data

Short-term traffic counts were conducted using accumulative count recorders (ACR). These

are portable, self-contained, “roadtube” type vehicle counting devices. Continuous traffic data were collected using permanent automated traffic recorders (ATR).

The ACRs provide 24-hour vehicle axle counts for the entire roadway cross section (i.e., in both travel directions). The distribution of ACR count sites by functional class is shown in Table 8. These data are analyzed to provide traffic-volume counts necessary for the publication of traffic maps, travel trends (AADT and VMT), and truck traffic-flow maps. These data are used to forecast future traffic volumes for pavement design, and for special studies as requested. This information is furnished to the Federal Highway Administration (FHWA), Districts, Divisions, and other state agencies and the public as requested.

The ACRs are used to conduct areawide traffic counts in the state’s urbanized areas. At the time of this study, the Research and Development Section was conducting five of these urban area “blanket counts” per year, an increase from two per year in 1983. At this rate, each of the state’s urbanized areas would be recounted on a five-year cycle.

The ACR devices are also used to conduct traffic volume counts on the state’s “off-system” bridges (approximately 15,000 sites) and on those county roads which connect with the state highway system. Traffic volumes on these county roads have not been counted since 1975. In the future, the Research and Development Section plans to conduct traffic volume counts on these county roads every three years.

In 1983, the ACRs were used to conduct approximately 42,000 traffic volume counts throughout the state. In 1990, it was estimated that the ACRs would perform approximately 62,000 traffic volume counts. This increase in the number of traffic counts is due to the accelerated urbanized area traffic counting schedule and various federal mandates (e.g., Highway Performance Monitoring System (HPMS), Strategic Highway Research Program (SHRP) and the Traffic Monitoring Guide (TMG)).

Table 8
Distribution of Short-Term (ACR) Count Sites by Functional Class
TxDOT

Functional Class	Number of Sites
Rural	
Interstate	620
Other Principal Arterial	3,167
Minor Arterial	2,671
Major Collector	13,212
Minor Collector	5,653
Local	<u>176</u>
RURAL TOTAL	25,499
Urban	
Interstate	535
Other Freeway and Expressway	495
Other Principal Arterial	3,103
Collector	173
Minor Arterial	2,154
Local	<u>26</u>
URBAN TOTAL	6,486
TOTAL	31,985

The Department's ACR (short-term) traffic counts were conducted by contract labor. The Research and Development Section provided the ACR devices and all other tools and accessories needed to conduct the traffic counts. The Research and Development Section developed a detailed performance plan to ensure the quality and accuracy of the ACR traffic counts.

Standard field practice for the ACR program was for the data collection technician to install the equipment and then observe it for several minutes to determine whether the axle counts recorded correspond to those actually observed. If not, the unit was replaced with another; and the questionable device was returned to the central office. In addition, the counting results were compared in the office to the previous year. If there was a significant unexplained change, the site was recounted.

Field supervisors visited the ACR traffic data collection locations on a rotating schedule that covered every machine for 15 minutes at least four times per year. They observed the counting by the equipment to determine if the device was miscounting.

In response to recent HPMS Field Manual directives, the Research and Development Section instituted procedures to create and maintain records of the accuracy checks made for each ACR machine. The test data were retained for each machine and included, as a minimum, a percentage of all axles sensed and the date and location of the testing. ACR machines that were observed to produce errors of 10 percent or more were repaired or replaced.

Continuous traffic data were collected using permanent, automated traffic recorders (ATR). Data from the ATRs were retrieved by an automated polling system and used primarily to develop seasonal (i.e., monthly) adjustment factors for expanding short-term (ACR) counts to estimate AADT. These data were also used for forecasting future traffic volumes and pavement design and for special studies as requested. This information was furnished to FHWA, Districts, Divisions, other state agencies, and the public. The distribution of ATR sites by functional class is shown in Table 9. Also shown in Table 9 is the distribution of ATR sites on HPMS sample sections.

Table 9
Distribution of ATR Sites by Functional Class
TxDOT

Functional Class	Total ATR Sites	ATR Sites on HPMS Sections
Rural		
Interstate	21	11
Other Principal Arterial	37	9
Minor Arterial	18	1
Major Collector	20	1
Minor Collector	3	0
Local	<u>0</u>	<u>0</u>
Rural Total	99	22
Urban		
Interstate	32	25
Other Freeway and Expressway	6	4
Other Principal Arterial	10	3
Collector	0	0
Minor Arterial	2	1
Local	<u>0</u>	<u>0</u>
Urban Total	50	33
TOTAL	149	55

The management and analysis functions for the ATR data were accomplished through a completely computerized process using high speed microcomputers and the Department's mainframe computer. It was also the Department's intent to integrate the battery of microcomputer-based traffic monitoring data processing programs under development by FHWA when they became available. It is expected that a larger proportion of the data processing will be carried out on microcomputers.

Because all of the Department's ATR sites are accessed via a telemetry system, it was necessary only to monitor the data to determine if significant changes have occurred. This was accomplished using a computer program that compared daily results with those obtained at the same site during the previous year. If an unusual change was detected, a diagnostic program was run for the ATR site via the telephone line. If problems were detected or if the pattern continued, a

technician was dispatched to the site to observe the operation. The counts produced by the ATR were then compared to those observed by the technician. If problems were observed, the equipment was either repaired on the site or a replacement unit was installed; and the faulty device was returned to the central office in Austin for repair. Machines that were observed to produce errors in excess of 2 percent were repaired or replaced.

Automation of the ATR program resulted in a significant reduction in the length of time that any ATR site is out of order. Malfunctions are detected on the same day that they occur, and a technician is dispatched to make a repair or replacement.

In addition, each ATR site is visited at least once every three months to verify the accuracy of the operation. By direct observation, it is determined whether the equipment is miscounting the passing vehicles.

In response to the HPMS directives, the Department initiated new procedures to verify the accuracy of each ATR. This will be done on a three-year cycle. Vehicles in each lane will be manually counted for one hour. The test data will be retained for each machine and will include, as a minimum, the percentage of all vehicles that were sensed and the date and location of the testing.

Vehicle Classification Data

The vehicle classification program in Texas during the study period consisted of 995 unique data collection samples that were obtained over a three-year cycle; there were four consecutive six-hour shifts by a crew of four data collection technicians. The result was a continuous 24-hour data collection session at each of the sites. The distribution of the sites by highway functional class and HPMS volume group is shown in Table 10. In addition, approximately 125 additional vehicle classification sessions were conducted each summer at locations for which site-specific data were needed.

Table 10
Distribution of Texas Vehicle Classification Sites by HPMS Volume Groups and Functional Class

HPMS Volume Group*	Rural Interstate	Rural Other	Urban Interstate	Urban Other
1	12	703	2	47
2	13	132	6	8
3	7	34	4	3
4	2	9	3	
5	3	2		2
6		2		
7		1		
8				
TOTAL	37	883	15	60

* Appendix F of the HPMS Field Manual defines 13 traffic volume groups by functional class and area type (rural, small urban, and urbanized).

The FHWA Traffic Monitoring Guide (TMC) recommends a minimum of 300 48-hour vehicle classification measurements over a three-year cycle. In response to this recommendation, the Department prepared procurement specifications for 100 automatic vehicle classification (AVC) devices. A major program installed permanent axle sensors at 432 current and proposed vehicle classification sites plus approximately 100 Strategic Highway Research Program Long-Term Pavement Performance (SHRP LTPP) monitoring sections. This equipment was used to conduct 48-hour vehicle classification data collection at each site during each year, which resulted in the following numbers of classification data collection sessions per year:

<u>Fiscal Year</u>	<u>24-Hour Classification Sessions</u>
1989-90	432
1990-91	1194
1991-92	1274

The 432 24-hour vehicle classification sessions for FY 1989-90 were all manual efforts. The 1194 sessions for 1990-91 included 432 manual 24-hour sessions, 50 AVC sessions, and 712 quarterly sessions at the 89 SHRP sites. The 1991-92 sessions also included the data from ten additional SHRP sites.

The manual vehicle classification data were acquired as hourly totals for each of the vehicle types shown in Table 11. The 24 hourly totals for each vehicle type were summed to yield a daily total.

Table 11
FHWA Vehicle Types

Type	Description
1	Motorcycles (optional)
2	Passenger Cars
3	Other 2-Axle, 4-Tire Single Unit Vehicles
4	Buses
5	2-Axle 6-Tire Single Unit Trucks
6	3-Axle Single unit Trucks
7	4 or More Axle Single Unit Trucks
8	4 or Less Axle Single Trailer Trucks
9	5-Axle Single Trailer Trucks
10	6 or More Axle Single Trailer Trucks
11	5 or Less Axle Multi-Trailer Trucks
12	6-Axle Multi-Trailer Trucks
13	7 or More Axle Multi-Trailer Trucks

The manual vehicle classification counts, which were replaced by the AVC program, were checked in two ways. First, the results were compared to the previous year to determine if a significant unexplained change might require a recount. Second, supervisory personnel made occasional unscheduled visits to the data collection sites to ensure that the work was conducted as planned.

When the AVC equipment was received, procedures were implemented for checking the accuracy of the data being acquired. Records were created and maintained that indicate (1) the date

and location of the testing and (2) the number and percentage of vehicles accurately classified in each of the 13 FHWA vehicle classes. A tolerance of 10 percent of all vehicles was proposed for AVC units.

Speed Data

Speed data were collected in 24-hour counts at approximately 33 locations on a quarterly basis for the national 55-MPH Speed-Monitoring Program. This analysis conducted on various classified highways served as documentation for the annual certification that the state was enforcing the national speed limit. The speed information was analyzed in accordance with guidelines developed by the FHWA and reported in the prescribed format so that uniformity is attained on a national level.

Truck-Weight Data

Truck-weight data were collected at 48 sites in the state for development of the 18-KIP Equivalency File and the HPMS and SHRP programs. Twelve of the sites were permanent weigh-in-motion (WIM) stations that were operated three times per year in 48-hour sessions. These stations collected data on four lanes at a time. The remaining 36 stations used portable WIM equipment to gather truck-weight data three times a year in 24-hour sessions. The portable equipment collected data on only two lanes at a time.

In response to SHRP requirements for general pavement studies (GPS), the Research and Development Division implemented a compromise between the desirable and minimum levels of effort required by SHRP. WIM data were obtained from each SHRP LTPP GPS test section continually for seven days twice per year in each of two quarters (either first and third or second and fourth). Data were to be collected during the other two quarters in the following year.

Data Analysis

While the Research and Development Section was responsible for the Department's basic traffic data collection programs, the responsibilities for data analysis were shared by the three sections (Administrative Operations, Transportation Systems Planning and Research and

Development) within the Transportation Planning Division. Table 12 lists the primary statistical reports compiled by the Division and identified the section(s) responsible for these reports. As shown in Table 12, the Administrative Operations Section maintained inventories of current facilities and conditions, the Transportation Systems Planning Section projected for traffic data, and the Research and Development Section compiled current traffic data.

The following sections of this chapter describe the procedures used by the Research and Development Section to analyze traffic data. The discussion focuses on procedures employed to estimate average annual daily traffic (AADT), development of seasonal adjustment factors, estimation of vehicle miles of travel (VMT), and analysis of vehicle classification data. TTI completed an analysis of the Research and Development Section's traffic monitoring program, and much of the following material is extracted directly from the research report (1142-1F, *Analysis of Texas Traffic Monitoring Program*) which documents the results of that study.

AADT values were calculated for each ATR site as the 365-day average of the traffic volumes observed at that site. TxDOT adopted the policy of rejecting data from ATR sites that did not have at least 14 full days of data per month.

Data from the ATR sites were used to develop monthly adjustment factors for expanding short-term (ACR) counts to AADT. Texas practice was to develop these adjustment factors for the group of ATR sites in the region of the state in which the sites were located. The Department assessed the desirability of following the Traffic Monitoring Guide recommendation of developing adjustment factors by functional classification. Mean monthly adjustment factors were calculated for each ATR site for each month as the ratio of the 365-day traffic volume average to the average weekday for each individual ATR. The group monthly adjustment factors were then computed as the mean of the individual monthly adjustment factors for the ATR sites assigned to the group. The group factors were updated monthly. Day-of-the-week factors were not calculated.

Table 12
Summary of Statistical Traffic Reports Compiled by the Transportation
Planning Division of TxDOT

Subject	Contents	Submittal Format	Date	Lead Section
Highway Performance Monitoring System	Data determine the geometric characteristics of the roadway, governmental jurisdiction, and traffic for all public road mileage plus additional data for sample sections.	Magnetic Tape	June 15	A
Motor Vehicle Accident Summary	Motor vehicle accidents by federal aid system and functional classification, by accident severity.	Prepared Form	June 15	A
Mileage and Daily Travel Summary	Miles and vehicle miles by rural, small, urban, and each urbanized area, by functional classification.	Prepared Form	June 15	A
Lane Miles	Miles, lane miles, and vehicle miles by selected highway systems; by county; and by rural/urban.	Computer Listing	Dec. 31	A
ROW Acres	Right-of-way acres, roadbed and surface acres; by selected highway systems, miles and acres; by county or District.	Computer Listing	Dec. 31	A
Milepost File	Ground milepost by signed highway system and number equated to control, section, and milepoint.	RIS	Monthly	A
Annual Miles and Vehicle Miles by Various Highway Systems, Roads, and Streets	Miles and vehicle miles for highways, roads, and streets by federal aid, by rural or city, by District, by county.	Computer Listing	Dec. 31	A
Vehicle Classification	Title self-explanatory.	Computer Printout	Annual	A, R
Truck Weight Study	Title self-explanatory.	Computer Tape	May	R
Accumulative-Count Recorder (ACR) Data	Date, volume, and direction of traffic.	Computer Tape	Quarterly	R
State, District, County, and Urban Transportation Study Area Traffic Maps	Title self-explanatory.	Maps	When revised	R
Report on Maps Produced	Maps produced under HPR Program.	Map Information List	July 15	P
Automated Traffic Recorder (ATR) Data	Date, day, hour, volume, and direction of traffic.	Computer Tape	Monthly	R
Vehicle Speed Studies	Analysis of vehicle speed on prescribed types of highways at statewide locations.	Computer Printout Summary Report Factor Sheet	Quarterly and Annually	R

Table 12 (Continued)
Summary of Statistical Traffic Reports Compiled by the Transportation
Planning Division of TxDOT

Subject	Contents	Submittal Format	Date	Lead Section
RI-2 Traffic Log	Current and projected traffic volumes applicable to R1-2 Official Mileage Record.	Computer Printout	Initial and upon request	P, R
R.L. 2 Revised Road Life Record	Reflects all state contracts and a complete historical record of all highways on the state-maintained system.	Strip map	On request	A
Bridge Log	Complete historical record of all bridges on the State-maintained system.	Computer printout	As revised	A, P
Defense Bridges & Pre-Attack Input Data	Detailed bridge data, location and ADT on the defense system.	Computer Tapes, Maps	Bi-annual Maps-odd years; Tapes-even years	P
Structural Inventory and Appraisal of the Nation's Bridges	Reflects structural and inspection data along with data of inspection.	Computer Tape	Twice monthly	P
RI-1 Log Straight Line Diagram	Graphic presentation of all roads on the State System showing identification, location, characteristics, maintenance section responsibility, milepoints and mileposts.	Strip Map	Initial and upon request	P
RI-2 Official Mileage Record	Basically the same data as shown on RI-1 in coded form.	Computer Printout	Initial and Upon request	A
Interstate System Needs Estimate	Reflects cost showing the amounts of funds required to complete the interstate system.	Bound Books and Strip Maps	Required by Congress every 2 years	A
All-System Needs Study	Requested by Congress; the required data are usually requested on a sample study of highway mileage.	Computer Tapes and Published Reports	On request	A
PR-5111 Report Status on the Interstate system	Coded status of the interstate system by routes	Straight line Diagram	Upon revision	A
Railroad Crossing	Reflects the rail road crossing and data for crossings on all public roads and highways	Tape	Quarterly	P
Special Traffic Studies	Traffic data that are not available through the normal traffic information collection program	Tape or Prepared Form	As required	R
Traffic Data Projections	Data for use in highway design, environmental statements, air quality and noise level analysis, signalization studies, and various administrative highway programs	Tabulation or Narrative Form	Upon request	P

Expansion of Short-Term Counts

AADT values were calculated for each short-term (ACR) count for each year from the total axles counted on that section, adjusted for the total number of axles per vehicle and monthly variation according to the following equation:

$$\text{AADT} = \text{Total axles} \times \text{axle factor} \times \text{monthly factor}$$

Axle correction factors were produced to adjust the observed axle counts to yield numbers of vehicles. Vehicle classification data provided the basis for this adjustment. Factors were developed for each functional class in each highway district within the state from sites located accordingly. Table 13 shows the form used to calculate axle correction factors based on the manual classification categories.

Data were acquired usually in the same quarter of the year in each District. The AVC program implemented produced vehicle classification data at each of 432 locations. Under this revised program, the data were collected for 48 continuous hours.

Future system-level axle correction factors will be based on at least 50 sessions of vehicle classification per year for each functional class in both rural and urban categories. The vehicle classification categories that will be used for the AVC operations will be those shown previously in Table 11. The factors will be updated annually.

The axle factor applied to the 24-hour axle count at each HPMS section was determined by the Highway District of the section.

All AADT values are rounded according to the following criteria:

<u>Volume Range</u>	<u>Round to Nearest</u>
10 - 1,000	10
1,000 - 2,000	50
2,000 - 20,000	100
> 20,000	1,000

Discussion

TTI analysis produced the following assessment of the adequacy of the state's traffic monitoring program relative to the FHWA Traffic Monitoring Guide and the Strategic Highway

Research Program. The Traffic Monitoring Guide states that during each year the following minimum (default) values for data collection programs should be established: one-third (1/3) of the HPMS sample sections should be counted for at least 48 continuous hours; 100 vehicle classification locations should be selected from the HPMS counting locations and monitored for 48 continuous hours, with a different 100 sites being monitored each of the following two years; 30 truck weighing sessions of 48-hours duration are needed each year in each state, with a different 30 sites being monitored each of the following two years. The result of these traffic monitoring efforts is that all HPMS sample locations, 300 vehicle classification sites, and 90 truck weighing locations will be monitored during a 3-year cycle. States which do not wish to use FHWA default values for the number and distribution of data collection stations are provided with statistical procedures for designing their own programs based upon their own data files.

The traffic volume counting and vehicle classification recommendations were not inconsistent with Texas practice in terms of the number of sites. However, the 48-hour duration suggested by FHWA would have serious impacts upon both programs. The traffic counting would be substantially more costly and the acquisition method (manual counts) for vehicle classifications would be impractical.

Table 13
Axle Correction Factor Worksheet
TxDOT

DATE _____		
DISTRICT _____		
STATION _____	DIRECTION _____	HIGHWAY _____
<u>VEHICLE TYPE</u>	<u>VEHICLES</u>	<u>AXLES</u>
PASSENGER CARS	_____	X2=_____
TRUCKS, SINGLE UNIT: PICKUP & PANEL	_____	X2=_____
TRUCKS, SINGLE UNIT: 2 AXLE/6 TIRE	_____	X2=_____
TRUCKS, SINGLE UNIT: DUAL REAR	_____	X2=_____
TRUCKS, SINGLE UNIT: 3 AXLE	_____	X2=_____
COMBINATION SEMI: 3 AXLE	_____	X2=_____
COMBINATION SEMI: 2S2	_____	X2=_____
COMBINATION SEMI: 3S1	_____	X2=_____
COMBINATION SEMI: 5 AXLE	_____	X2=_____
COMBINATION SEMI 6: AXLE	_____	X2=_____
DOUBLE BOTTOM: 5 AXLE	_____	X2=_____
DOUBLE BOTTOM: 6 AXLE	_____	X2=_____
TRUCK AND TRAILER: 3 AXLE	_____	X2=_____
TRUCK AND TRAILER: 4 AXLE	_____	X2=_____
TRUCK AND TRAILER 5 AXLE	_____	X2=_____
TRUCK AND TRAILER 6 AXLE	_____	X2=_____
BUSES-COMMERCIAL: 2 AXLE	_____	X2=_____
BUSES COMMERCIAL: 3 AXLE	_____	X2=_____
BUSES-SCHOOL: 3 AXLE	_____	X2=_____
MOTORCYCLES	_____	X2=_____
TOTAL VEHICLES _____		TOTAL AXLES _____
AXLE FACTOR = TOTAL VEHICLES/TOTAL AXLES		

The 50 states, by following FHWA minimum recommendations, would have a total of 1500 48-hour truck weighing sessions annually. This number is in contrast to the level of 600 Truck Weight Study sessions annually, most of which were for less than 24 hours of weighing. The FHWA recognized that a change of this magnitude in the truck weighing programs would require the use of weigh-in-motion (WIM) equipment to automate the process. However, although Texas had a longstanding commitment to WIM research and usage, it was not in conformance with that document at the time the FHWA TM Guide was issued. This is due to the apparent requirement for 30 unique WIM locations each year. This condition was remedied.

TTI Report 1142-1F, *Analysis of Texas Traffic Monitoring Program*, offers the following TM Guide-related recommendations. First, it is recommended that the Department develop seasonal adjustment factors based on functional class. Department practice based seasonal adjustment factors on geographic (regional) site classifications. Second, it was found that the number of ATR sites in the state could be reduced and still meet the prescribed tolerances given in the TM Guide. It was recommended that the number and locations of the Department's ATR equipment be reviewed to determine whether some of this equipment could be relocated as needed to provide site-specific traffic estimates that are required for Department uses but not necessarily available from the traffic data activities mandated by either HPMS or the TM Guide.

SHRP developed guidelines for preferred, desirable, and minimum data collection efforts for General Pavement Studies. Continuous weigh-in-motion is preferred for each General Pavement Study (GPS) test section. This provides continuous traffic volume, vehicle classification, and truck weight data for the SHRP section. For many states, including Texas, this is not feasible.

If continuous collection of WIM data is not feasible, SHRP recommends continuous collection of AVC data for 365 days per year on each SHRP LTPP GPS test section for the duration of the LTPP monitoring activity. This was to be operational by June 1991. A minimum level is specified as one continuous, 365-day count at each SHRP section and was to be completed by June 1992. The Department responded to the SHRP LTPP statement of needs by undertaking the installation of an infrastructure consisting of inductive loops, axle sensors, and cabinets to house the AVC electronics at each SHRP LTPP GPS test section. Department personnel used these facilities to acquire AVC data for seven days in each month for the duration of the SHRP LTPP monitoring

activity. The weeks were rotated each year to provide full AVC coverage of all weeks of the year by the end of 1993.

On the subject of collecting truck weight data when continuous collection of WIM data is not feasible, SHRP recommends obtaining axle weight samples using WIM equipment at each SHRP LTPP GPS test section for a one-week period during each truck season. This is the desirable level of effort. A truck season was defined as a period of time during a calendar year when a significant change occurs in expected truck weights or volumes. The SHRP document indicates that if the truck seasons are not known, the seasons of the year (i.e., quarters) should be followed. The SHRP memorandum also says that if it is not possible to obtain a one-week sample in each season, the minimum level of effort is to acquire a continuous 48-hour sample for Monday through Friday and another continuous 48-hour sample for the weekend during each season.

The Department chose to implement a compromise between the desirable and minimum levels of effort described in the previous paragraph. WIM data were obtained from each SHRP LTPP GPS test section continually for seven days twice per year in each of two quarters (either first and third or second and fourth). Data were collected during the other two quarters in the following year.

The preceding sections of this chapter have focused on the Department's traffic data collection programs. While these programs provided extensive data concerning the magnitude and composition of traffic on the state's highway system, no comparably comprehensive programs were available to compile the additional data needed for travel demand modeling, either at the state or local level. The Department needed to expand and/or supplement the state's data collection efforts to include origin-destination (O-D) data, household travel data and survey procedures, and sociodemographic, economic, and land use data. While fiscal constraints precluded a comprehensive, statewide travel demand modeling data collection program, the Department identified opportunities for gathering travel demand data either as part of the Department's ongoing traffic data collection programs and/or through improved coordination of other data collection efforts at the state and local levels. For example, the Department supported an extensive transportation research program. Many of these research projects required substantial data collection efforts. The Department established procedures for reviewing and coordinating these data collection efforts to maximize the utility of the resulting data bases beyond the immediate needs of a specific research project. These procedures

addressed standardization of data collection methods and reporting formats, and established a process for assessing the feasibility of expanding individual research project data collection efforts to include the collection of additional data to supplement existing data bases.

To improve traffic forecasting and modeling capabilities, the Department must improve its data collection programs.

CHAPTER 4

TxDOT POLICY AND ADMINISTRATIVE REQUIREMENTS OF TRAFFIC DATA

INTRODUCTION

Accurate and timely traffic data are basic to the entire transportation planning process and are essential to enable TxDOT to effectively meet the mobility needs of the state. This is particularly significant since the ISTEA created the first federal mandate for statewide multimodal/intermodal planning. ISTEA provisions amplified the importance of collecting, processing, and analyzing traffic data. Emphasis on planning, the environment, intelligent vehicle highway systems, and the development of management systems requires increases in the resources allocated to traffic data collection and analysis. At the time the interviews were being conducted, rule making related to traffic monitoring systems required by ISTEA was in progress.

The overall goal of Research Project 1235 was to improve the quality of the state's planning data, planning techniques, and the timeliness of traffic data preparation. Evaluating TxDOT's traffic data collection and analysis programs and developing recommendations to improve the effectiveness and efficiency of this program were goals of this study.

The Policy and Administrative Requirements task of the research project investigated the relationship between traffic data and policy and administrative requirements for those data. In order to prepare a comprehensive review of current practice, identify traffic data requirements, and document appropriateness of existing conditions, a survey of TxDOT and the FHWA staff was conducted. The investigation to determine that relationship focused on TxDOT and FHWA professional and administrative personnel.

PURPOSE AND METHODOLOGY

A review of policy and administrative requirements for traffic data was accomplished by interviewing TxDOT administrative staff and the four TxDOT Divisions thought to be most actively involved in using traffic data. Fourteen interviews were conducted with staff from the Bridge and Operations Division, the Planning and Policy Division, the Highway Design Division, and the Maintenance and Operations Division. In addition to TxDOT personnel, administrative staff from

both the FHWA division office in Austin and the FHWA regional office in Fort Worth were interviewed (eight FHWA staff interviewed).

Individual questionnaires, based on area of responsibility, were prepared for each professional interviewed and furnished sufficiently in advance to allow thoughtful consideration of the areas to be addressed. Letters of transmittal indicated that the questionnaires were only working documents to stimulate discussion and that conversation would not be limited to the specific questions asked. A personal interview was then arranged to allow verbal responses to the questions.

EXECUTIVE SUMMARY

It would be difficult to overstate the significance of traffic data and their relevance to TxDOT policy and administration. Accurate and timely traffic data are of considerable consequence in strategic planning, fund allocation, project evaluation and prioritization, program formation, environmental analysis, and, ultimately, project design.

The “General Conclusions” and “Specific Conclusions” sections of this chapter documents Transportation Planning Division’s perception that it is addressing TxDOT Division and Administration, as well as FHWA, traffic data needs as adequately as possible given personnel allocations. Areas are identified, however, where those interviewed perceived traffic data needs that are not being met, areas where needs are being met but the level of accuracy is not satisfactory, and needs that are being met but time required for preparation is so long that work goes on without benefit of accurate data.

PROJECT SELECTION AND PROGRAMMING

TxDOT expends significant resources in its annual construction program addressing the various needs of the highway system. This construction program managed through TxDOT’s Project Development Plan (PDP) is updated annually. This 10-year planning document is a means for selecting, prioritizing, scheduling, funding, and developing projects. A TxDOT task force determined that TxDOT PDP was one of the best systems in use in the United States. This research reviewed the individual program elements of the PDP to evaluate the traffic data significance to the planning process.

At the time this study was conducted, project priorities in general were determined by the TxDOT Commission (now the Texas Transportation Commission). Three broad categories of projects, preservation, mobility, and strategic priority, comprised the framework for inclusion in individual development plans; the three categories were further divided into programs of work allowing TxDOT to address specific needs of the system.

In September 1991, the Task Force for the Review of Planning, Programming, and Scheduling of Construction Projects recommended that the Department's top priority be system preservation and that funding should be 42 percent of the total construction program. Funds were allocated, based in large part on traffic data, to preventative maintenance, rehabilitation, bridge rehabilitation/replacement, safety, and discretionary. According to *Report of the Task Force for the Review of Various Aspects of the Project Development Plan Process*, October 1994, TxDOT's highest priority remains preservation of the existing transportation system. However, adequate revenue has not been allocated to accomplish that goal. With the exception of 1992, actual expenditures for preservation has not reached, and in some years has fallen significantly below, the 42 percent recommendation. The 1993 PMIS data indicate that the system is deteriorating at an annual rate of 2 percent since FY 1990 and will continue to do so until "the trend of spending less than the recommended percentage of dollars was halted." The Task Force recommended that preservation expenditures be raised to 43 percent and that "actions be taken to ensure that those apportionments are actually used to bring contracts to letting."

At the time this study was conducted (1989-1991) North American Free Trade Agreement (NAFTA) was not a factor in either preservation or mobility projects. However, NAFTA's ratification has brought new challenges to the goals of preservation and to mobility. This category addresses the need for increasing the capacity of the system. The mobility program accommodates the building of new roadways, adding lanes to existing highways, or managing the traffic on existing facilities. Funding is determined by the Commission after consideration is given to the other work categories. Projects compete for funding on a statewide priority based on their relative cost-effectiveness as determined by a Cost Effectiveness Index (CEI). The CEI ranks projects based on the time it would take user benefits to pay for the proposed facility. Input variables used to calculate the CEI include present average daily traffic (ADT), percentage truck traffic (T), and average

directional distribution (D), as well as other variables. At the time study was conducted, programs under the mobility category included new highways, additional travel lanes projects (sometimes referred to as expansion projects), interchange project evaluations, traffic management systems, specific systems projects, and rail/highway grade crossing protection programs.

The Strategic Priority category of work is made up of projects that will not meet the criteria for the other categories but are worthwhile projects which promote economic growth, provide continuity for transportation systems of other states and countries, and provide access to significant local, state, and federal facilities. These projects are not ranked in order of priority, and often the projects have not been funded. The 1994 Task Force examined the Strategic Priority program and recommended procedures to ensure that projects in this category are accomplished and not overlooked.

GENERAL CONCLUSIONS

Forecast traffic is not used for the project selection-prioritization-programming process if “forecast” is defined as a look at future years. If forecast does include estimates (an interpretation of existing traffic parameters), then it is used in the project selection process.

TxDOT Division and Administration, as well as FHWA, primary applications and their explanations as determined from the interviews conducted are listed below:

Traffic Estimates

Strategic Planning. Strategic planning is almost completely dependent on traffic data. According to Associate Executive Directors and the Director of the Planning and Policy Division, traffic data on a system basis are most important to the TxDOT Commission because allocation of resources is based on traffic.

Department of Commerce Projects. TxDOT cooperatively participates in Department of Commerce projects such as “Team Texas” (Texas’s commitment to encourage specific economic development). TxDOT determines the amount and nature of traffic which will be induced by new traffic generators, such as new businesses, and investigates opportunities to accommodate these new generators with adequate transportation facilities.

Highway Performance Monitoring System (HPMS). HPMS consists of all public highways or roads within the state with the exception of roads functionally classified as local (HPMS = 5,500 Texas samples). Approximately 100 data items are collected including traffic volumes, annual vehicle miles traveled (AVMT), average annual daily traffic (AADT), vehicle classification, and truck weight. Average annual daily traffic is perhaps the most variable data item in the HPMS.

Bridge Needs Investment Program (BNIP). The BNIP is a 100 percent Texas sample for traffic data purposes.

Funding Needs Determinations. Traffic data are used as an important variable in determining both long- and short-range needs.

Project Selection-Prioritization-Programming (including cost-effectiveness). Associate Executive Directors emphasize that every TxDOT program is based on traffic data.

Operational Improvements Design. Elements of design for operational improvements are directly related to traffic data.

Preservation of the System Allocation Programs. These programs use various combinations of lane-mile/traffic/population as the basis for distributing funds to each program as previously discussed.

District Allowable Obligation Authority (letting caps). With exception of preservation projects, the district allowable obligation authority is determined by a formula based on the percentage of district VMT.

Cost Overrun Justification. Occasionally, receipt of bids prior to the award of the construction contract indicates that the project will overrun the amount of funds set aside for that project. Evaluating whether to let the project overrun and justifying project overruns is based on the cost-effectiveness of the project. Traffic data are essential to this evaluation process.

Modal Split. Classification counts and forecasts are important for evaluating the division of trips between modes of transportation.

Delegation Requests. Delegation requests are reviewed and recommendations are sent to the Commission based on traffic and cost-effectiveness. Forecast traffic for the requested improvement is provided to the Commission.

Capacity Analyses. Highway project type and scale of design are determined by capacity

analyses. These calculations are extremely sensitive to traffic data variables and are important factors in determining project costs.

Load Zoning and Structural Adequacy. Wheel load counts help determine structural adequacy and TxDOT system load zoning. For instance, it is estimated that loads as high as 142,000 pounds are entering the system at the Texas-Mexico border.

Evaluation of Proposed Legislation. TxDOT is routinely called upon to evaluate the effects of legislation pertaining to maximum vehicle weights. Traffic data will be critical if the legislature attempts to statutorily return to a geographic area funding equivalent to the motor fuel tax revenue received from that area. Without the ability to determine dollar income amounts, VMT in the area would be the logical basis for distributing funds.

Federal Highway Administration Applications. FHWA uses TxDOT traffic estimates for an overview of the planning process and for verifying individual project proposals. Although the Division office performs an annual review of the data manipulation upon receipt of the TxDOT submission, Highway Performance Monitoring System (HPMS) data are not used in either the Division or Regional offices. FHWA's primary concern is that the data are correct and that TxDOT has followed the FHWA Traffic Monitoring Guide or an equally acceptable process. The HPMS data are forwarded to FHWA for analysis and assembly into a national report.

Allocation from the Highway Trust Funds to the individual states is determined at the federal level. Although population is the key factor, statewide VMT is one of a multitude of factors considered in the complex formulas. VMT also determines the amount of interstate maintenance and safety funding allocated to each state. State allocations are generally based on previous allocation, plus a minimum allocation formula.

Traffic Forecasts

Strategic Planning. It is essential for TxDOT Administration to know total statewide VMT in order to assist in plan preparation for the State Comptroller's Strategic Goals, Legislative Appropriation Requests, legislative liaison, special Commission requests, delegations appearing before the Commission, needs estimates, tactical plans, and budgets. In the opinion of some TxDOT administrative staff, an overall statewide VMT is so important that final approval should be made

by the TxDOT Commission.

ISTEA Management Systems. The six management systems and the traffic monitoring system required by ISTEA will be a massive database that should be used in the strategic planning process. Further discussion of the relationships between traffic data and the management systems is included in the “Specific Conclusions” section of this report.

Level of Service. TxDOT Commission determines the level of service of a proposed facility for project authorization (comparative analysis).

Facility Requirements. Determining facility requirements for designs and standards (bridge width, design speed, shoulder width, clear zone width, number of lanes required, lane width, weaving lanes, pavement design, etc.) is based on forecast traffic, thus impacting the estimated cost, cost efficiency, etc.

Projected Highway Needs. HPMS and BNIP are used for needs analysis and to create the strategic mobility plan. Future highway project needs are used to determine overall funding requirements. These traffic variables are also used to prepare estimates of pavement deterioration under future conditions.

Advanced Planning Process. Associate Executive Directors agreed that TxDOT has never adequately used available traffic data for the advanced planning process. Important policy issues need to be addressed and appropriate models need to be put to use.

Environmental Analysis (Air Quality and Noise Studies). Traffic data must be adequately addressed to assess impacts under the Clean Air Act Amendments of 1990 (CAAA). If traffic and emissions are inadequately evaluated, TxDOT could make unnecessary emission reductions.

Concern exists that other governmental agencies, consulting firms, and even the general public should be able to access TxDOT’s traffic information and use it in their environmental impact analyses so all planning organizations will have current and reliable data.

Interregional Demand Flows. Estimates of interregional demand flows and forecasts are a missing link in the current system analysis, strategic planning, and allocation process. Intercity route planning is currently conducted on a case-by-case basis. A lack of objective criteria exists to evaluate system issues such as continuity or economic benefits as part of route studies. Methodology needs to be developed to assist in quantifying intercity route demand, evaluating proposed new routes or

major upgrades to existing routes, and upgrading a statewide intercity route plan such as the Trunk Line System Plan.

Federal Highway Administration Applications. Traffic forecasts are used by FHWA for individual project level analysis. FHWA staff evaluates the designs proposed by TxDOT. Forecast design year traffic is essential in performing the capacity and level of service and in determining facility requirements mentioned in previous discussions. Forecast traffic is particularly important in review of design standards as well as interchange design.

In response to questions regarding accuracy of forecasts, those interviewed stated that the TxDOT Transportation Planning Division needs to review past forecasts. These reviews should compare office forecasts with what actually occurs on the ground after the project has been developed. This system of review is being investigated as part of the ongoing project research.

FHWA also mentioned the diversity of the estimating and forecasting traffic procedures used by Metropolitan Planning Organizations (MPOs) and cities across the state. MPO staff expertise ranges from nonexistent to excellent in the area of traffic forecasting. It was suggested that TxDOT play an expanded role in developing standards for such work and in generating instructional manuals to be accompanied by training and continued technical assistance.

Traffic Assignment

Associate Executive Director and Division Perceptions. Interviews with Associate Executive Directors as well as Division personnel indicated that they do not use traffic assignments. Computerized travel demand modeling has been the basis for the transportation system planning process for 30 years. Extensive research has been devoted to improving the accuracy of the models in predicting travel and assigning that travel to transportation networks, but use of these data for developing traffic forecasts for project planning and design in urban areas is questionable. The accuracy of these system-level forecasts, or assignments, is dependent on the data used in calibrating models, the validation process, and the forecast of variables such as population, dwelling units, employment, and land use. Extreme variance in trip-making characteristics in different urbanized areas as evidenced by travel surveys was mentioned. Concern existed that, although the Transportation Planning Division controls the modeling process, MPOs with various levels of

expertise in this field were forecasting variables. This, in turn, controls the output of the models.

FHWA Applications. ISTEA and the CAAA place importance on traffic assignments. Traffic assignments are the basis for evaluating conformity to air quality standards and mandated reduction in pollution levels. In addition, FHWA reviewed traffic assignment data in individual urbanized areas to assure that goals of the overall urban planning process were being met and that the urban plans were based on logical traffic data. Assignments were also used for backup information on corridor analysis traffic data which are furnished by the Division as documentation of individual project proposals. On occasion, FHWA has reviewed individual TxDOT assignment models and found them to be adequate. Accurate and timely traffic forecasts (particularly total statewide VMT) are essential for the Planning and Policy Division to establish overall direction for TxDOT. Forecasting plays a fundamental role as Planning and Policy Division attempts to predict the future, set goals to meet the prediction, and specify strategies to implement the goals.

The Planning and Policy Division was responsible for the TxDOT Strategic Plan, the Comptroller Strategic Trends, and the Governor's Strategic Goals. These consisted of long-term strategies and six-year plans for operation to include vision, mission, goals, strategies, and performance measures. Planning and Policy coordinated Legislative Appropriation Requests, legislative liaison, and special Commission requests. The long-term direction provided guidance for preparing tactical plans and budgets by other Divisions.

Departmental Needs Studies established funding amounts and assessed the severity of scope of needs as well as the extent of the problem to be addressed. Long-term strategic needs and investment analyses were made using the HPMS model (uses VMT forecasts). Studies also evaluated internal capabilities such as assessing TxDOT capabilities and reviewing available personnel, equipment, and funding resources.

Legislative Appropriation Requests are a result of strategic planning. Motor fuel tax revenue projections are made using the TxDOT HIFUND model (using VMT forecasts).

General Comments

General traffic comments received during the interviews include:

- Time is of the essence; a statewide GIS system is needed.

- This statewide system should include a database which has current and forecast traffic (RI2T Log) volumes on all roads. One should be able to look on a screen and read data and not wait for a long forecasting process, except in a corridor analysis situation where a trendline/linear regression traffic projection would not reflect changing project criteria. This would reduce the number of Transportation Systems Planning Division requests and the delay in information.
- More time must be spent looking at transition corridors and modes and modal splits.
- MPOs should explain to urban decision makers the importance of rural roadways and that it is not just rural drivers that use rural roads. Rural roads must be upgraded for commerce to serve urban areas.
- Emphasis should be placed on the high speed rail. Training programs should include information on application and technology associated with high speed rail systems.
- TxDOT was admonished to look at intercity corridors; this automatically puts the agency into interregionalism issues.

SPECIFIC CONCLUSIONS

There is no general knowledge of how frequently traffic data requests were made of the Transportation Systems Planning Division. Most traffic data requests were made during preparation of the annual Project Development Plan (PDP). Approximately 1,200 projects were usually requested at that time. Divisions used data furnished by the districts, who used the Division data on a daily basis. Districts challenged the data if they consider them to be inaccurate.

Timeliness of traffic estimates and forecasts was also generally disputed. Some of those interviewed indicated a perception that response time depended on who made the request for the data and how large the request was. Comments ranged from a very good response time to fair and poor. The Dallas District experienced process delays in updating their PES program; it takes one year to collect the data (January to December) and then another five months to update the file. This meant that the available data could be six to 18 months old. Accurate data should be available at all times to Districts, divisions, and administration on the mainframe computer and should be updated at least annually by the Transportation Systems Planning Division.

Administrative staff understand little about the present traffic data analysis procedures. It was the consensus of the interviews that accuracy of the information was unknown. A general perception was that there was too much expansion of the data to synthesize information for uncounted locations. One division observed ten-fold variations in many 18 KIP Single-Axle (KSA) projections from one year to the next. It was suggested that uncounted sections should not be estimated or extrapolated synthetically unless noted on the data. It was also perceived that the Transportation Planning Division made assumptions regarding the percentage of trucks on the system (i.e., the percentage of trucks on all farm roads). This was unrealistic, particularly in such areas as oil fields, timber areas, etc. Traffic data such as truck factors, design hourly volumes, and directional distribution are critical for design and environmental analysis.

The highest degree of accuracy is needed. One interviewee suggested that the Transportation Planning Division establish a system for reviewing past forecasts to compare them with actual count data to establish credibility of their forecasting ability. It was also suggested that documentation of the process for establishing the data and forecasts should be available.

Among division concerns about the traffic estimation and forecasting procedures were accuracy and timeliness, but the greatest concern was the need to develop an automated system and database that could be accessed without submitting a request for data. For example, a Division makes a request of the Transportation Planning Division; the Division will search the computer and puts data on paper; the Transportation Planning Division transmits the paper to the requesting division; and the division puts the data back into the computer. It was suggested that GIS capabilities combined with a statewide database could make traffic data immediately available at the nearest computer. However, a mainframe system would not replace the need for individual traffic forecast data. The Transportation Planning Division would still require a more sophisticated process for estimates for design purposes.

It was the unanimous conclusion of the interviewees that more traffic counts, classification counts, and wheel load data were essential; adequate manpower and sufficient modern equipment were not being dedicated to this effort. More TxDOT resources needed to be dedicated to collecting, analyzing, and reporting traffic-related data. Databases need more frequent updating. The Transportation Planning Division's mechanics for updating were too time-consuming. If TxDOT

manpower cannot be allocated to the process, the Transportation Planning Division should seek outside contractors. The Bridge Division stated that axle spacing data were virtually nonexistent and that they also needed more timely off-system railroad and bridge counts. According to the Bridge Division, the Planning and Policy Division found 40 percent error (missing traffic counts) in off-system bridge files. It is possible that allocation formulas inadequately take truck traffic into consideration (more research needed).

Some division staff recommended that the Transportation Planning Division initiate a research project on traffic directional distribution. They also felt that Division had insufficient data for modal distribution and that they should have better population data. The Planning and Policy Division and the Department of Commerce furnished population numbers for suballocation of funds.

Some concern was expressed regarding the appropriate role of the districts in collecting, analyzing, and forecasting traffic data. The general consensus was that districts should be involved in the collection process because they have better knowledge of when and where to collect the data. Districts should not be required to analyze or forecast. Districts should recount traffic shortly after capacity improvements are made (Bridge Division).

Both RI2T Log traffic files and RIS files are used to secure traffic data for program purposes or index calculation. One division indicated that on some occasions these two files are inconsistent. This should not occur since the Transportation Planning Division input the traffic information to the RIS file. There was also some concern that traffic data for the BRINSAP file (BRINSAP does not address axle spacing) were not the same as in other files. All computer databases should be consistent.

A TxDOT internal review concluded that the forecasts from the 10-year trend line method gave high results. TxDOT concluded that the RI2T Log projections did not consider system changes or land use changes and that this might seriously affect the use of traffic projections on some roadways.

Generally, it was perceived that procedures used by MPOs for estimating and forecasting traffic was quite divergent in accuracy, resources, and methodologies. Opinions were also expressed that TxDOT must require MPOs to build planning staff and assist the staff in being trained to use traffic data. It was suggested that TxDOT develop a course of instruction on how to use traffic data,

similar to the course they developed for the design schools. Both MPO and TxDOT personnel would benefit by such training.

ISTEA Requirements

ISTEA requires that states develop, establish, and implement a system for managing highway pavements, bridges, safety, traffic congestion, public transportation systems, and intermodal transportation facilities. Additionally, Transportation Management Areas (TMAs, areas with a population of 200,000 or more) are required to include a Congestion Management System as part of their transportation planning process. All management systems will require some degree of traffic data analysis.

Pavement Management System. TxDOT's current Pavement Evaluation System (PES) will be converted to a Pavement Management Information System (PMIS) by early 1993. PMIS will utilize traffic data (primarily 18 KIP Equivalent) to predict pavement performance; correlate past performance with truck traffic; select and rank projects; and determine current funding requirements by district, by PDP category, and by year. Traffic data are, of course, essential to the PMIS.

Congestion Management System (CMS). A CMS that provides for effective management of new and existing transportation facilities through the use of travel demand reduction and operational management strategies is required of all TMAs. In TMAs that contain areas classified as nonattainment for ozone or carbon monoxide, highway projects which will significantly increase capacity for single occupant vehicles must be part of an approved CMS. Traffic data analysis will be a significant consideration of this management system.

RECOMMENDATIONS

Due to the significance of the overall VMT forecast, the following are recommended for consideration:

- Divisions should share expertise in VMT forecasting. Both the Planning and Policy Division and the Transportation Planning Division have personnel with analytical and technical skills. A technical work group could be formed to include the two Divisions and possibly the Finance Division for financial input. The Planning and Policy Division might also benefit

in analyzing population/VMT trends to assist the Transportation Planning Division.

- A variety of methods should be used to generate a range of forecast VMT values to give alternatives for consideration. Variables used should accompany output information. More dynamic modeling techniques should be considered for this element (possibly including variables such as population, fuel sales, employment, or freight movement). As a long-term objective, alternative scenarios might consider transit trends, growth, environmental controls, trade, etc., and how these factors will affect the overall and regional VMT.
- Considerable research is needed to improve data quality and validate the state level VMT estimation process. VMT may be commensurate with population projections for the state and regions.
- Since more than one division either prepares or uses long-term VMT forecasts, there should be a cooperative consensus-building process regarding forecast values over the planning horizon.
- A model was developed by the Texas Transportation Institute (TTI) in 1982 to forecast Texas VMT as a function of gasoline price, population of licensed drivers, and gross state product. The model can be used to produce demographic and economic scenarios in conjunction with traffic forecasts. TxDOT should have TTI reestimate the parameters in the model using more recent data.

In order to improve traffic analysis, documentation, and reporting systems, the following are recommended for consideration:

- Methodology needs to be developed to assist in quantifying intercity route demand, to evaluate proposed new routes or major upgrades to existing routes, and to use the methodology to upgrade a statewide intercity route plan such as the Trunk Line System Plan. A lack of objective criteria exists for evaluating system issues, such as continuity of economic benefits, as part of route studies.
- The Transportation Planning Division should establish a system for reviewing previous forecasts by comparing them with actual ground count data to measure the accuracy of the forecasting process. This will establish credibility of forecast data.
- Funding allocation formulas should be reviewed to determine whether truck traffic factors

are adequately being considered.

- More TxDOT resources should be dedicated to collecting, analyzing, and reporting traffic-related data.
- TxDOT should develop a statewide traffic database available through GIS and make this information accessible to users both inside and outside TxDOT.
- Documentation of TxDOT's collection, analysis, forecasting, and reporting procedures should be developed and distributed to promote credibility of traffic data and forecasts.
- The districts' role in traffic counting should be reviewed. Districts should recount traffic shortly after capacity improvements are constructed.
- All TxDOT computer databases should be consistent.
- TxDOT should develop a training course of basic instruction on traffic data. TxDOT should also play an expanded role in developing standards for MPO traffic analysis and should generate instructional manuals to accompany training and technical assistance. Both MPO and TxDOT personnel would benefit by such training.
- Divisions should share expertise by developing a task force to consider improvements to traffic data collection, analysis, and reporting.
- TxDOT would benefit by an organized evaluation of techniques and processes used by other states. Results of this research should be well documented and reviewed by a task force (such as the one mentioned above) for possible transformation to TxDOT applications.
- Consideration should be given to establishing a coalition with other states or with AASHTO to set up a technical based conference for information exchange. Such an exchange program would promote better understanding of the overall needs and existing methodologies in traffic data collection, analysis, and reporting.
- A personnel exchange program should be developed with other states and FHWA to promote on-the-job training.

SOURCES CITED

TxDOT Division manuals, policy and procedure publications, strategic plans, and internal review correspondence, in evaluating TxDOT policy and administrative requirements of traffic data were used as general reference. The FHWA "Traffic Monitoring Guide" was also used to evaluate procedures for collecting and analyzing data.

CHAPTER 5

TxDOT DISTRICT OFFICE REQUIREMENTS FOR TRAFFIC DATA

INTRODUCTION AND SUMMARY

This chapter summarizes the findings and conclusions from a series of interviews conducted with each TxDOT District Office during the study period. For most districts the researchers were able to meet with the district engineer, the district design engineer, the district planning engineer, and the district traffic engineer in a single group interview. Oral interviews were conducted using a set of questions which were furnished to the districts in advance. A set of these questions is shown as Figure 10 at the end of this chapter. The interviewers exercised judgment in the execution of the interview, because the questions were not equally applicable to all districts. For example, rural districts would not have had an occasion to use traffic assignments developed through the urban transportation planning process. As it turned out, the answers to the questions were remarkably similar among all districts. In retrospect, it may not have been necessary to interview all 24 districts. However, the researchers did not know this in advance, so interviews were conducted with all districts. The anecdotal information varied considerably among districts and this contributed to an interesting set of interviews.

The results of the interviews can be briefly summarized as follows:

- All the districts rely heavily on traffic estimates and traffic forecasts produced by the Transportation Planning Division.
- The districts found the traffic estimates and the traffic forecasts to be accurate for the purposes for which they are used.
- The timeliness of the traffic estimates and traffic forecasts produced by the Transportation Planning Division was satisfactory for most districts.
- None of the districts routinely collected traffic data, developed traffic estimates, or developed traffic forecasts for their own use nor did they want to have the responsibility for doing so. The exception was that the districts collected limited traffic volume data for traffic signal warrants and for signal timing applications.

The interviews are summarized under the main headings of application of traffic data,

administrative issues, traffic data collection, traffic data analysis, rural traffic forecasting, urban traffic forecasting and route studies.

APPLICATION OF TRAFFIC DATA

District traffic requirements, defined in terms of end uses, are identified in this section. The Transportation Planning Division provided the districts with three forms of traffic data: estimates of existing traffic, forecasts of future traffic, and travel model traffic assignments showing volumes for forecast traffic for proposed future year transportation networks. The primary uses and applications of traffic data by the districts is summarized as follows:

Traffic Estimates

Project Development Plan (PDP). The PDP is partially based on cost and vehicles miles of traffic. Therefore, it is necessary to provide traffic estimates for each proposed PDP project. These traffic estimates are updated each time the PDP is updated and when there is a significant change to a PDP project.

Design. Traffic estimates are needed for geometric and pavement design for rehabilitation projects, for added capacity projects, and for new construction projects.

Traffic Signals. Traffic estimates are used for signal warrants and for signal timing application. Most districts collected these traffic data themselves without assistance from the Transportation Planning Division.

Environmental Assessments. Traffic estimates are used to prepare estimates of the noise and emission impacts of proposed projects.

Public Inquiries. Districts are frequently asked to provide information on traffic volumes on specific facilities to the public, engineering firms, business and development interests, and other government agencies who use them for a wide variety of applications. The districts prefer to use the traffic volume maps prepared annually by the Transportation Planning Division for this application when the maps are available on a timely basis.

Traffic Forecasts

Planning. Planning is a primary application of traffic forecasts by the districts. Typically, the urban transportation plans are updated every five years if not more frequently. The planning process relies heavily on traffic forecasts.

Design. Traffic forecasts are used for geometric and pavement design for rehabilitation projects, for added capacity projects, and for new construction projects.

Environmental Assessments. Traffic forecasts are used to prepare estimates of the noise and emission impacts of proposed projects.

Traffic Assignments

Planning. Planning is the primary application of the traffic assignments prepared by the Transportation Planning Division for the districts and the primary source of forecast traffic used by metropolitan planning organizations (MPOs). Typically, the urban transportation plans are updated every five years. Traffic Assignments are now updated only every 10 years rather than 5 years due to the limited numbers of modeling staff. For large urban areas, significant changes may be more frequent. The planning process relies heavily on traffic assignments to evaluate proposed planning alternatives. The alternatives analysis process narrows the range of possible future transportation options and assists in the decision-making process. Once an alternative is selected, the traffic assignment for that alternative becomes the basis for the development of the project-specific traffic forecasts that are used for environmental assessment and design (geometric and pavement). Although critical to the work of the districts, the districts make little direct use of the traffic assignments which are in the form of tabular data provided on computer output paper and network maps with posted forecast traffic volumes. The computer output tables and the posted network maps are used heavily during the evaluation of proposed transportation system alternatives, a part of the planning process. This work is usually done by the MPOs in cooperation with the district transportation planning engineer. Interestingly, many districts did not know where the latest traffic assignment tables and maps for their district were located or how to read the output tables. The reason for this is the districts rely on the Division to provide forecast traffic for specific projects. Consequently, the Division's corridor analysis staff, who are responsible for preparing project-specific traffic forecasts,

are the primary users of the traffic assignments for this application. The districts recognized the importance of traffic assignments but are not the primary direct users.

Design. The output of the traffic assignments is used for geometric and pavement design for rehabilitation projects, for added capacity projects, and for new construction projects, but not directly. As discussed above, the use of traffic assignments for this application is primarily by Division staff and not district staff.

Environmental Assessments. Traffic assignments are not used directly for environmental assessments but used as input to the process which develops refined traffic forecasts for air and noise analysis for proposed projects.

Accuracy of Traffic Data

The accuracy of the traffic estimates and the traffic forecasts provided by the Transportation Planning Division was judged to be sufficiently accurate for the district's purposes by almost all districts. For pavement design, the districts thought in terms of getting the base course design correct to the nearest one inch of base and the surface course design correct to the nearest one-quarter inch of asphaltic concrete (ACP). These thicknesses are the minimum that a road contractor can control during construction. The accuracy expectations for some districts were that estimated traffic should be within plus or minus 5 to 10 percent of the true value and that forecast traffic (opening year plus 20 years) should be plus or minus 20 to 25 percent. Many districts did not have an opinion on what the accuracy of the traffic estimates or traffic forecasts should be. Actually there appeared to the interviewers to be little concern by the districts about the accuracy of the traffic data provided by the Division. This supports a conclusion that the traffic data being provided are in fact sufficiently accurate for the districts applications. District responses to the accuracy question are summarized in Table 14.

Timeliness of Traffic Data

The question of the timeliness of the traffic data requested of the Transportation Planning Division by the districts solicited a variety of responses. Most districts reported that their time needs for traffic data were met most of the time. Almost every district had some exceptions to share,

occasions when the traffic data requested were not available within the time requested. Most districts had an appreciation for the periodic heavy work loads imposed on the Division by project calls with short deadlines and, in particular, the need to provide updated traffic for all PDP projects at the same time.

Most districts expressed concern with the lack of timeliness in the preparation and publication of the annual Traffic Count Maps. These maps are easy to use and are used for a variety of applications. The district engineers and their senior staff did not understand why it took so long to publish these maps. They thought the maps should be published as they are prepared, not after all maps were completed. Not having timely traffic count maps caused the districts to have problems with the several publics they serve. The districts thought that the traffic count maps for the preceding year ought to be available by April 1 of the current year.

Effective Coordination

There were several suggestions for improved coordination and communications between the Transportation Planning Division and the districts which, if implemented, could lead to improved traffic data and delivery of traffic data services. Improved coordination between the district staff and Division staff as to when the annual traffic count program would be conducted in a district and the locations that would be counted would help identify locations where road or bridge construction would interfere with the planned count. In this case, the scheduled count may need to be rescheduled or omitted for that year. Currently, the staff has no way of knowing if the historical count location is being impacted by a construction project. As another example, recent changes in land use in the immediate vicinity of the historic count location can significantly impact a particular count because of localized traffic that is not representative of the roadway segment as a whole, a recently constructed truck terminal, for example. In this case, the historical count location may need to be relocated in order to maintain the historical trends. Again, the district staff, and not the Transportation Planning Division staff, is in the best position to be aware of such situations.

A few district engineers thought that the traffic estimation and traffic forecasting procedures were too much of a “black box” process. These engineers would like to have an improved understanding of what the procedures are. They thought that their staffs would be better able to

contribute to the process and make suggestions to improve the process, if it were more open and information about the process more readily available. The district engineers did not have specific suggestions on how this could best be accomplished other than perhaps having published procedures manuals available to the district. These comments apply to the basic traffic estimation and traffic forecasting procedures and not to the urban traffic demand modeling process. None of the district engineers thought that they would be able take the time to attend a course or workshop on traffic forecasting. Nevertheless several of them would like to have a more open process.

At one time the districts had a much larger role in the traffic data collection process. With perhaps two exceptions, the districts were not interested in getting back into the traffic data collection business, i.e., having district staff perform the traffic volume counts and the vehicle classification counts.

Finally, there is interest in the Department resuming their previous practice of counting traffic volumes on county roads every five years.

Table 14 summarizes by district the number of traffic requests submitted annually, the typical turn-around time needed, whether the traffic was provided within the needed turn-around time, whether the data were accurate for the district's purposes, and the level of accuracy desired.

Table 14
Summary of Traffic Application Comments from the District Engineer Interviews

District #	Name	Number of Requests Made per Year	Turnaround Time Need	Time Needs Met?	Are Data Accurate for Use?	Level of Accuracy Needed
District 1	Paris	estimates 6-8/year forecasts 10-12/year	less than 30 days	yes	yes	estimates 5% forecasts 25%
District 2	Fort Worth	capacity 8-20/year rehabilitation 10/year	2-12 months 4-8 weeks	yes	yes	no response
District 3	Wichita Falls	7-10/year	3 months	yes (80%)	yes	estimates 5% forecasts 20%
District 4	Amarillo	rehab. 10-12/year other 6/year	2-3 months	yes	yes	1" of base 1/4" surface
District 5	Lubbock	10-12/year	2 weeks	yes	yes	1" of base 1/4" surface
District 6	Odessa	12/year	2 weeks	no	yes	1" of base
District 7	San Angelo	10-15/year	2-3 weeks	yes	yes	no response
District 9	Waco	estimates 2/year forecasts 25/yr	2 weeks 2-3 months	yes	yes	estimates 10% forecasts 10%
District 10	Tyler	estimates 12/year forecasts 6/year	12 weeks 4 weeks	yes (80%)	yes (90%)	90%
District 11	Lufkin	12/year	12 weeks	yes (85%)	yes	± 20%
District 13	Yoakum	10-15/year	4 weeks	yes	yes	no response
District 16	Corpus Christi	6/year	?	yes	yes & no	no response
District 17	Bryan	12/year	15-30 days	yes	no	no response
District 18	Dallas	30/year	6 weeks	no	no ramp volumes	no response
District 19	Atlanta	estimates 0/year forecasts 3-5/yr	30 days	yes	yes	85%
District 20	Beaumont	2-3/month.	2-4 weeks.	yes	yes	no response
District 21	Pharr	20-40/year	6 weeks	yes	yes	no response
District 23	Brownwood	2-3/year	6 months.	yes	yes	no response
District 24	El Paso	15/year	3 months	yes	low	10%
District 25	Childress	6/year	1-2 months.	yes	yes	no response

ADMINISTRATIVE ISSUES

In this section, the responses to questions relating to staffing issues, responsiveness issues, policy-related issues, technology implementation issues, single source traffic issues, and other district concerns about traffic estimation and traffic forecasting are summarized.

Staffing Issues

Questions were asked concerning the number of planning staff, their training, promotion opportunity, compensation, and turnover.

Most districts reported that their planning staffs were adequate in size for the district's needs. For a few districts, the number of active projects and the time line for developing the projects resulted in their planning staffs being occasionally over-tasked.

In the area of staff training, a distinction was made between professional and technician staff training. In general, most professional staff receive adequate, appropriate, and timely training. However, there was concern that more appropriate training is needed for upper level professional staff, those having significant management responsibilities. The timing and appropriateness for some training was a concern. Some people were scheduled for specific training which, while not directly related to their current assignment, was expected to be beneficial in the long run.

Technical staff receive appropriate training, but this training, combined with inadequate levels of salary compensation, can lead to staff turn-over. Once skilled on various computer software applications and proficient in traffic analysis, it is not unusual for the employee to obtain a more lucrative position in the private sector. This seems to be more of a problem in urban districts than in rural districts.

Promotional opportunities are adequate for the entry-level engineer; but as the levels go higher, the opportunities for advancement become limited. As the job market for engineers expands, several districts expect to lose experienced professional staff to the private sector. Engineering staff were not leaving at the time of these interviews; the economic recession was cited as a primary factor. A second reason was the stability of state government employment which many engineers see as a plus.

The district engineers expressed limited concern about compensation and staff turnover/

retention. Salaries and benefits were considered fair by most districts. Engineering staff were not being lost to the private sector as they once were because of improved salary levels for engineering positions. For technical staff the situation was different. Apparently the entry level technical staff were employed with limited specific application skills. Once trained, their state salaries were no longer competitive with the private sector; and some chose to leave state employment. Also, technical staff have concerns with work hours and family needs and seek different schedules in an effort to meet family commitments.

Responsiveness Issues

This question relates to the responsiveness and ability of Transportation Planning Division staff to provide adjusted traffic estimates and forecasts to the districts within the time frames desired.

When asked to define timely availability, most districts responded that 30 to 90 days was very acceptable. However, the responses varied by district and by the type of projects in the district. Traffic data for rehabilitation projects were often needed within 15 to 30 days. For some urban projects, an initial or rough estimate of the traffic may be needed within 30 days. Often a rough estimate was adequate for the initial stages of an urban project. For these applications, the traffic data could be provided in a two-stage format, initial rough estimates followed up later by the refined traffic. However, this two-stage procedure was not generally used. Improved communication between the districts and the Division to clarify exactly what type of traffic data were needed and at what stage would allow them to be more responsive to the district needs.

Policy-Related Issues

The policy-related questions concerning truth in traffic data concepts, minimum traffic counting periods, present procedures for traffic data summarization, site-specific data collection, and standardized procedures for use by MPOs for estimating and forecasting household and employment variables for trip generation analysis were asked.

Truth in Data. An explanation of the truth in traffic data concepts was provided by the interviewer; specifically, the inferences drawn about data collected from traffic counters which were not operable for a part of the counting period and the practice by the Transportation Planning

Division of using traffic data from a roadway deemed similar to the requested roadway. The districts demonstrated an understanding of the truth in traffic data concept. However, most districts were not familiar with the issue and generally were not concerned. The overall impression was that the truth in traffic data issue is not a concern to the districts; and if it is an issue at all, it is the responsibility of the Division.

Minimum Counting Periods. Minimum counting periods for traffic volume counts (24-hour or 48-hour counts), vehicle classification counts, and WIM counts were not a concern to the district. These questions are a Division responsibility, not a district responsibility.

Several districts expressed concern about the season of the year when the counts were taken. The districts thought the highways that serve the beaches in the summer and ski slopes in the winter ought to be counted both in-season and off-season to provide an accurate picture of actual traffic conditions.

The districts preferred that vehicle classification counting periods be for a minimum of 24 hours. The vehicle classifications observed on some highways vary dramatically between day and night.

The districts thought that the Department of Public Safety ought to use the Department's weigh-in-motion (WIM) sites to enforce the state truck weight regulations.

Summarization of Traffic Data. The procedures used by the Division for traffic data summarization are considered to be adequate. However, the districts would like to receive counts by lane, not just a total count for a multi-lane facility. The districts were interested in knowing what factors were applied, what assumptions were made, and what was the "similar" location used for roadway counts. The suggestion was also made that the Division visit with district office staff when preparing traffic estimates and forecasts. Such visits would assist the Division in developing better forecasts and provide them additional insight into the districts' needs and their application of the forecasts.

Site-Specific Traffic Data. For some highways site-specific data are needed for accurate pavement design, such as roadways that serve specialized trucking operations (for example, oil field or logging operations). Truck traffic on a road serving a new oil field can destroy a highway in two months. The engineers acknowledged that this type of traffic cannot be forecast. Yet, estimates of

truck volumes need to be improved to ensure the accuracy of the forecasts. A few districts do site-specific data collection to supplement the Division counts due to the large volume of specialized truck traffic.

Technology Implementation Issues

The interviewers asked five questions regarding the procedures used to implement planning-related research. The responses were generic, however, and pertained to the implementation of research finding, in general.

Traffic Data Collection. The districts thought that decisions regarding the implementation of new traffic data collection procedures and equipment, new traffic data analysis methods, or improvements to traffic forecasting methods ought to be made by the Transportation Planning Division. If an engineer learns of a new technique or idea for traffic data collection, analysis, or forecasting by way of a conference or vendor and is interested in implementing this procedure, the engineer will make the suggestion or offer the information to the district engineer who may pass the information along to the Division or may make a decision to implement the practice locally.

Research Findings. How are research findings disseminated at the district level? The districts receive copies of published research reports, and the decision of what research findings to implement rests with the districts. The decision to implement research findings is made in different ways by the different districts. The majority of districts use an “individual initiative” driven process. A project engineer may choose to implement a research finding and, depending on the project, may seek approval from the district engineer before proceeding. Some districts use a committee process to implement research findings. The engineers within a district discuss the findings as a group and come to a decision regarding implementation of a particular research finding. The alternative to these two approaches is to wait to receive guidance or a directive from the appropriate division.

Planning-related research did not seem to have much direct application to the districts. Most TxDOT planning research was in support of the Division and was applicable to urban issues. Also, many districts did not appear to have a high level of interest in planning research, planning methods, or procedures. This is understandable to the extent that transportation planning is often thought of as simply traffic estimation and traffic forecasting. This work was done by the Division for the

districts. Planning documents are typically the responsibility of the MPOs; and while districts participated in the planning process, they were not responsible for developing the urban plans.

Researcher's Role. The researcher's role in the implementation process varied from active involvement to, more typically, no involvement at all. The districts expressed an interest in having some follow-up by the researchers in implementing the research findings. On occasion, districts called researchers for guidance and assistance in implementing research. Some review and follow-up process by the researchers or others responsible for technology transfer was considered crucial by some districts. Researchers were involved, at times, in the evaluation of research implemented by the districts. One suggestion was that the researchers should come to the districts and conduct a seminar on the research. The research findings could be introduced to the engineers and questions about potential application could be answered.

Research Reports. Research reports were distributed to the districts, and each district had its own circulation process. The resident engineers were usually given a copy of research reports to read and circulate. Resident engineers may review the reports' executive summaries at staff meetings. Some districts had a research coordinator tasked with the review, identification, and circulation of research reports to the appropriate engineers. The engineers were candid about their system for determining interest in a report. If the report title looks pertinent, they read the report; but more typically they read the findings and conclusions. One suggestion was to produce a video on an as-needed basis of new research highlighting findings, conclusions, and recommendations. Several districts subsequently interviewed thought that they would take the time to show a 10-15 minute research video during staff meetings. Another suggestion was to develop a format similar to the Highway Short Course to introduce research findings during a one- or two-day short course.

TRAFFIC DATA COLLECTION ISSUES

In this section, comments on the traffic data collection procedures, ACR locations, classification counts, and the use of traffic data from other sources is discussed. Most districts had limited comments on these questions.

Traffic Data Collection

The traffic data collection issues addressed the specific methods of collection and the use of ATRs, ACRs, AVCs and WIM equipment.

ATRs. The number of ATRs in the districts ranged from three to 14. The one comment made consistently was that the number of ATRs was not sufficient. Every district commented on a need to increase the number of ATR locations in their district. The reliability of the ATRs and associated telemetry equipment was reported to be good. The repair of the ATR equipment was not a problem. There was no concern about the accuracy of the ATR counts.

ACRs. Most districts thought that the system coverage of the ACR program was adequate. Delays in data entry were not a concern for the district except for the comments about the lateness in the publication of the traffic volume maps. To be useful to the districts, the traffic count maps need to be current; but the maps were consistently out of date.

AVCs. There were few comments about the AVC equipment or program. The accuracy of the AVC equipment was acceptable to the districts. Most did not have an opinion about the accuracy of this equipment.

WIM. The districts had few comments about the WIM equipment or program. They did not have an opinion about the accuracy of the data being developed by this program.

ACR Data Collection Issues. The ACR data collection program was a shared responsibility between the districts and the Transportation Planning Division. The districts wanted to know when the Division would be conducting counts. The districts wanted to have a count location map and a schedule in advance so that coordination could be achieved. Coordination of ACR counts with construction was of some concern, but the coordination of counter placement relative to land use considerations was not adequate.

The adequacy of the ACR coverage was judged to be sufficient. Some areas needed additional counts where there is significant seasonal variations in traffic volumes. If the district knew to what extent the volume changed during certain times of the year, it would be possible to adjust their pavement design thickness. For the most part, responsibility for off-system counts rested with the districts. Some districts supplemented the Division counts. Interestingly, most districts wanted to have the raw count, (axles counts divided by two) as well as the adjusted counts. The districts

were normally provided only the adjusted counts (AADT).

Classification Counts. There were few comments on the classification count program. This program was a Division responsibility and the districts, for the most part, were not involved. Delay in processing classification data, the adequacy of the system coverage, the off-system coverage, and the count durations were not of concern to the districts.

Traffic Data from Other Sources. In response to the question on the possibility of performing traffic volume counts for the purpose of HPMS and pavement management programs, the districts that responded were positive about the possibility of a data collection group at the district level; but they were also quick to point out the need for consistency among all districts and that additional staff would be needed for any new responsibilities.

The idea of developing a program to provide for the integration of traffic volume counts conducted by cities, counties, or contractors into a district-maintained traffic data file was not met with favor. The districts did not think that this was an idea worth pursuing. If such a program were needed, it should be handled by the regional planning agency (MPO). The districts used the traffic volume data they collected for signal warrants and signal timing studies. They were willing to share this data but were not interested in getting into the business of being a repository for traffic count data collected by others.

TRAFFIC DATA ANALYSIS

In this section, the responses to questions regarding the procedures used by the Transportation Planning Division to adjust raw count data, data processing concerns, coordination, and the procedures used to estimate traffic volumes for roadway sections that were not actually counted are summarized.

Adjustment to Raw Data

The districts were provided an opportunity to discuss any concerns that they had about the procedures used to adjust raw data. They indicated that the accuracy in whatever procedures were used needs to be ensured. A few districts cited a need for more interaction with the Division on the procedures used. Most districts did not know what procedures were used for the adjustment of raw

data. There were no concerns about the truck axle factors, daily factors, or seasonal factors used to estimate AADT. Most comments were broad-based and did not focus on any specifics.

Data Processing

There was limited concern about data processing procedures, the delay in processing raw data, or the problem of missing data due to equipment failure or some other factor. For the most part, the districts were not knowledgeable about these issues and thought that they were the responsibility of the Division. Again, the districts expressed a general concern that the Department do whatever was necessary to ensure an accurate data analysis process. Most everyone thought that the current procedures were, in fact, accurate.

Coordination

Most districts regarded the level of coordination with the Transportation Planning Division positively. A few noted that the Division was one of the better divisions to deal with. However, a few districts were not pleased with the coordination between the Division and their districts and felt that a higher degree of coordination was needed. The coordination needed was not specific to traffic data analysis issues but more to the question of timely information exchange and a higher degree of openness about how the Division does its work. Other coordination issues have been discussed above.

Traffic Estimation Procedures

In response to the question about the procedures used by the Transportation Planning Division to estimate traffic volumes where counts were not made, most districts did not have an opinion. Most districts did not know what procedures were used. A few commented that these procedures presented difficulty in urban areas but seemed to work well for rural areas.

RURAL TRAFFIC FORECASTING

Only a few additional comments on rural traffic forecasting were not covered in the section on the application of traffic data. Most districts thought that the rural forecasts provided by the

Division were reasonably accurate and timely. The rural traffic forecasting issues touched on the ten-year trend line forecast, the adequacy of the traffic counts and classification to support rural traffic forecasting, and the integration of the rural traffic forecasts with the RI2T Log.

Ten-Year Trend Line Forecast

For most rural applications, a forecast based on the ten-year trend line was acceptable and sufficiently accurate. The districts acknowledged that if their transmittal letter requesting a specific rural forecast contained information on recent or proposed land use changes that might impact the ten-year trend line forecast, the Division was able to account for these impacts. Where problems occurred, it was generally because the district assumed that Division staff had local knowledge that they did not have or because the district staff failed to advise Division staff of local changes that would impact a trend-line-based forecast.

Data Adequacy

Most respondents thought that there were sufficient traffic volume counts and vehicle classification data on which to base rural traffic forecasts. A few respondents thought that additional vehicle classification count locations were needed to properly represent the traffic and the pavement loadings. Again, the seasonal variation in traffic volumes and truck percentages was a concern to some districts. In those districts that have significant seasonal variation in traffic volumes or seasonal truck variation, for example, truck operations associated with the grain harvesting, there was concern that the Division counting programs are not adequately picking the seasonal variation.

RI2T Log

The RI2T Log was used as a source of rural traffic forecasts by some districts for a variety of tasks from advanced planning to preliminary design when the district was under a time constraint. Some districts were not aware that the RI2T Log contained traffic volume forecasts. Other districts used this source only as a last resort when a forecast was needed immediately and the turnaround time from the Transportation Planning Division was too long. Some districts used this source for initial work on the PDP. Most districts wanted the ability to obtain at least some traffic forecast

information on a real time basis, even recognizing that such forecasts could be used only for preliminary work. The RI2T Log appears to be the most appropriate existing source for these quick-and-dirty traffic forecasts. Some work to improve the computer routines used to produce the RI2T Log forecasts would be worthwhile.

URBAN TRAFFIC FORECASTING

Several questions dealt specifically with urban traffic forecasting issues: travel demand modeling (TDM), travel model validation, application of TDM forecasts, and integration of TDM forecasts with the RI2T Log forecasts. The responses to these questions are summarized in this section. In summary most districts had little specific knowledge of the urban travel forecasting process and consequently had few specific comments or concerns. Again, most districts viewed the urban travel forecasting process as a Division responsibility. Few district planning staff were directly involved in the details of these procedures and, for the most part, there did not appear to be a need for district staff to be involved in the details. A few district engineers expressed a desire to know more about the process; but when questioned about how much time they would be willing or able to devote to learning more about the process, no one was willing to spend more than a few hours to improve their understanding of the process. Consequently, there was no need to provide training to the districts to improve their understanding of what goes on inside the “black box”.

Travel Demand Modeling

The interviewers asked the districts to comment on several alleged criticisms of the TDM process. One criticism was the lack of user flexibility for analyzing traffic assignment output. The districts considered the TDM process and the traffic assignment forecast output to be acceptable as it was. The districts thought that they should know what the basis for the TDM forecasts were and make adjustments as appropriate. Some thought that the forecasts tended to be consistently on the high side. Others had no opinion about forecasts being too high or too low. Most were willing to accept the forecasts as prepared. Recall that most districts do not use the output of the traffic assignments directly.

In response to the criticism that the districts lack access to the TDM process, most districts

did not express any concern about access to the process. There were no opinions about the need for or desirability of having uniform traffic forecasting guidelines. However, most districts understood the need for a single source of traffic forecasts for needs estimates, programming, geometric and pavement design, and commission briefings with the Division having this responsibility.

There was some support for the idea that different forecasts could be prepared in stages or levels of detail depending on the specific application of the forecast. Aggregate level forecasts could be appropriate for the early stages of a project when several alternatives were being evaluated followed by a single, detailed disaggregate forecast once the preferred alternative was selected. Some engineers thought that the forecasts could be tailored to different levels of detail depending on the specific application. However, there was not a great deal of appreciation for this concept because few district staff had any idea of the amount of Division labor associated with a particular traffic request. In general, most district staff did not understand if a particular request for traffic would require a week of staff work or three months of staff work. There definitely was an opportunity to make more effective utilization of Division staff labor if requests for traffic could be more closely matched to the district's application of the forecast. This would require a greater appreciation on the part of the district staff of the amount of work required to perform certain forecasting activities and a greater appreciation on the part of Division staff of the various applications of traffic forecasts by the districts. Some districts allowed that they sometimes requested traffic at a greater level of detail initially than was really needed, because eventually they would need that level of detail.

Few districts had any comments regarding the possible integration of the traditional mainframe modeling process with personal computer software such as TRANPLAN. There was no interest on the part of the district staff interviewed to use TRANPLAN at the district level for evaluation of alternative proposed transportation networks. This capability should reside with the Transportation Planning Division and, if desired, with the MPOs.

Validation

The districts were asked to comment from a management perspective as to why it takes so long to validate an urban study. The engineers observed that the validation process was extensive and complex. The many facets of the process required that examination of all data be thorough and

comprehensive. There can be no question about the validity of the process and agreement that nothing should be done to expedite the process at the expense of accuracy. Aside from these general comments, the districts did not have an understanding as to why the validations often take a long time to complete. Urban study validations are a Division responsibility and were not an immediate concern to the districts.

Application of TDM to Small Urban Areas

Partially in response to practices in some other states, the districts were asked if they saw any benefit to the application of TDM methods to urban areas of less than 50,000 population. Did the districts think that the forecasting methods being used were adequate for these urban areas, or were improved forecasting processes needed? In general, the districts saw no need for application of TDM methods to smaller urban areas. Comments ranged from the effort would be a waste of time to the possibility that it ought to be explored. The only constraints offered were that the size of the area be at least 10,000 population or larger to warrant the effort that would be required.

Integration with the RI2T Log

The RI2T Log contains computer-generated traffic forecasts for all roadway sections, urban and rural. The question was asked as to how the RI2T Log was updated for urban sections. Also, the question was asked as to the extent that TDM-based forecasts ought to be integrated into the RI2T Log. Most districts responded that the log is not updated, it was not used, or it was not known how the log was updated. Several districts thought that the TDM forecasts ought to be integrated into the RI2T Log annually or as often as the TDM forecasts became available. This supports an earlier finding that the districts want to have a source of traffic forecasts that can be consulted on a real time basis. There was no expectation that these forecasts would be sufficiently accurate for all applications but an expectation that they ought to be sufficiently accurate for strategic and tactical planning (needs estimates, programming and public presentations, commission hearings).

ROUTE STUDIES

Two questions were asked under this topic regarding the need for or desirability of having interregional demand flow estimates and forecasts and the need for the Department to exercise greater control of access to system roadways.

Interregional Demand Flow

Interregional demand flow models characterize the movement of persons and goods between and among regions or cities. The models do not produce traffic suitable for geometric or pavement design. The models are usually not even route specific; rather they provide a measure of the affinity for commerce and other travel among regions or cities. The districts were asked whether data of this type would be of value to them.

Several districts thought that this information could be better utilized by TxDOT administration or divisions than by the districts because of their functions. Such information would be helpful to the districts from a public affairs standpoint. However, the districts do not need this information to accomplish their mission. Several engineers said that they had no use for this type of information and that the chambers of commerce might be interested in the information but not the districts. Two possible needs that might be met would be to border districts that have interstate traffic attributed to the Maquiladoras and perhaps to districts with seasonal traffic attributed to access to beaches or the ski slopes. Overall, the districts did not support a need for interregional demand flow information.

Access Control

Historically TxDOT has exercised limited control of access to system roadways. Lack of access control has contributed to reduced LOS for through traffic on many facilities initially designed for through movement.

Responses to the question of increased access control varied. Although most districts agreed that this was a problem area for them, not all the districts wanted any help from Austin. An increase in access control as a policy or standard would be viewed favorably by some districts. Median opening are a problem for many districts. There was some support for the Department to develop

standards for the frequency of median crossovers on 4-lane divided highways (non-controlled access roadways). There was one suggestion that such standards be made a state law with the districts responsible for the law's enforcement. Some districts would welcome guidance on access control but not a standard. These districts preferred that the responsibility for access control remain with the districts.

Figure 10. District Engineer Interviews.

1. Application of Traffic Data

- a. What are the primary district applications of:
 - i. Traffic estimates?
 - ii. Traffic forecasts?
 - iii. Traffic assignments?
- b. To what extent does planning lead the programming process?
- c. In this district, what is the general process used to identify projects that:
 - i. Involve new rural roadways?
 - ii. Involve additional capacity to existing rural roadways?
 - iii. Involve new urban roadways?
 - iv. Involve additional urban capacity?
- d. About how many times a year are requests made to the Transportation Planning Division for estimated or forecasted traffic?
- e. How quickly do you need these estimates or forecasts?
- f. Is the Transportation Planning Division usually able to meet your time needs?
- g. Are the estimates and forecasts provided by the Transportation Planning Division accurate for the purposes for which they are used?
- h. What level of accuracy is needed?

2. Administrative Issues

- a. Staffing Issues
 - i. Number of planning staff - adequate?
 - ii. Training - adequate?
 - iii. Promotion opportunity - adequate?
 - iv. Compensation - adequate?
 - v. Retention/turnover - acceptable?
- b. Responsiveness Issues
Goal is for timely availability of adjusted traffic or forecasted traffic for planning and design.

Figure 10. District Engineer Interviews (Cont.)

- i. What is meant by timely availability?
- ii. Has “timely” been defined with respect to the following?
 - (1) Advanced planning
 - (2) Design
- c. Policy-related Issues
What is your perspective on the following policy-related issues:
 - i. Truth in traffic data concepts?
 - ii. Minimum counting periods for traffic volume, classification, or WIM counts?
 - iii. Present procedures used for traffic data summarization?
 - iv. Site-specific data collection to support traffic forecasts for certain types of projects?
 - v. Standardized procedures to be used by MPOs for estimating and forecasting household/employment variables for trip generation analysis?
- d. Technology Implementation Issues
 - i. What process is used to implement new traffic data collection, data analysis, or traffic forecasting methodology into the district?
 - ii. Who makes the decision to implement planning research findings into the district?
 - iii. Who decides?
 - iv. What role, if any, do the researchers have in implementing research findings into the districts?
 - v. How are planning research reports distributed to potential users?
- e. Single Source Traffic
 - i. The Transportation Planning Division is responsible for review and approval of all traffic. Does this eliminate significant district participation in traffic data collection, analysis, or forecasting?
 - ii. What is the appropriate role, if any, for the districts in the collection, analysis, and forecasting of traffic data?

Figure 10. District Engineer Interviews (Cont.)

- f. District Concerns
 - i. What are your concerns, if any, about current traffic estimation procedures?
 - ii. What are your concerns, if any, about current traffic forecasting procedures?
 - iii. What are your concerns, if any, about current planning procedures?
 - iv. In your opinion, what would be examples of significant improvement in data collection, analysis, forecasting, or planning?

3. Traffic Data Collection Issues

- a. Traffic Data Collection Issues
 - i. ATR
 - (1) Number of ATRs?
 - (2) System coverage?
 - (3) Reliability of ATRs?
 - (4) Telemetry?
 - (5) Delay in data entry?
 - (6) Repair?
 - (7) Accuracy standards?
 - ii. ACRs
 - (1) Accuracy standards?
 - (2) Automation of data transfer?
 - iii. AVCs
 - (1) Accuracy standards?
 - (2) Delay in processing data?
 - iv. WIM
 - (1) Portable WIM
 - (a) Accuracy standards?
 - (b) System coverage?
 - (2) Permanent WIM
 - (a) Accuracy standards?

Figure 10. District Engineer Interviews (Cont.)

(b) System coverage?

- b. ACR Data Collection Issues
 - i. District responsibility?
 - ii. Adequacy of system coverage?
 - iii. Responsibility for off-system counts?
 - iv. Coordination of scheduling?
 - v. Coordination with construction?
 - vi. Coordination of counter placement and land use considerations?
 - vii. Count duration?
 - viii. Availability of raw data versus adjusted data?
- c. Classification Counts
 - i. District responsibility?
 - ii. Delay in processing data?
 - iii. Adequacy of system coverage?
 - iv. Off-system coverage?
 - v. Count duration?
- d. Traffic Data from Other Sources
 - i. What do you think about the feasibility of a data collection group at the district level for HPMS and PM data?
 - ii. To what extent are traffic data collected by districts, cities, counties, or contractors integrated into district files?

4. Traffic Data Analysis Issues

Do you have any concerns about the procedures currently used for:

- a. Adjustment to Raw Data
 - i. Truck factors?
 - ii. Daily factors?
 - iii. Seasonal factors?
- b. Data Processing

Figure 10. District Engineer Interviews (Cont.)

- i. Delay?
- ii. Imputation of missing data?
- c. Coordination
 - i. Between the Division and districts?
- d. Estimation Procedures
 - i. Procedures used to estimate traffic volumes for segments where counts were not made?

5. Rural Traffic Forecasting Issues

With respect to traffic forecasting for rural sections (outside the MPO boundaries) do you have any concerns about the procedures used to prepare the forecasts:

- a. Ten-Year Trend Line Forecast
- b. Data Adequacy
 - i. Traffic counts?
 - ii. Classification data?
- c. Integration with RI2T Log
 - i. What are the primary uses for the traffic projections in the RI2T Log?
 - (1) Project selection?
 - (2) Commission briefings?
 - (3) Release to the public?
 - ii. The projections in the RI2T Log do not consider system changes or lane use changes. Does this seriously effect the use or application of traffic projections in the RI2T Log?

6. Urban Traffic Forecasting Issues

- a. TDM
 - Process has been faulted in following areas. Can you amplify on these areas?
 - i. Lack of user flexibility in analyzing the output?
 - ii. Lack of access to the process by the districts?
 - iii. Lack of uniform traffic forecast guidelines?

Figure 10. District Engineer Interviews (Cont.)

- iv. Does the Transportation Planning Division need a single project forecast for needs estimates, programming, geometric and pavement design, and for commission briefings?
- v. Can we use different forecasts for different purposes?
- vi. If so, how can we move in this direction?
- vii. Integration with TRANPLAN?
- viii. Integration with UTPS?
- ix. Lack of clear, easy to understand explanation of TDM?
- b. Validation
From a management perspective, what are your observations on why it takes so long to validate an urban study?
- c. Application of TDM
Potential use of TDM methods by the Division or at the district level for other than large urban areas?
- d. Integration with RI2T Log
 - i. How is the RI2T Log updated for urban sections?
 - ii. Should TDM forecasts be integrated into RI2T Log?
 - iii. If so, with what frequency?
 - iv. Would these projections be satisfactory for strategic and tactical planning (needs estimates, programming and public presentation, Commission hearings)?

7. Route Study Issues

- a. Interregional Demand Flow
What use could the district make of these demand flow estimates and forecasts?
- b. Access Control
Historically the Department has exercised limited control of access to system roadways. Lack of access control has resulted in reduced LOS for through traffic on many facilities initially designed primarily for through movement. To what extent, if at all, should the Department exercise greater control of access?

CHAPTER 6

RURAL, INTERCITY, AND STATEWIDE TRAFFIC FORECASTING

GENERAL

This chapter presents a review of practices in rural, intercity, and statewide traffic forecasting at the time of the study. The review distinguishes between rural traffic forecasts which are typically site-specific forecasts used for pavement design purposes, and intercity and statewide traffic forecasts which are link or network forecasts used for various transportation planning studies.

The presentation begins with documentation concerning TxDOT procedures and the problems and shortcomings associated with these procedures. This is followed by a review of practices in other states with an emphasis on alternatives to current TxDOT practices. This chapter concludes with a summary of general recommendations for improving the Department's rural, intercity, and statewide traffic forecasting procedures.

RURAL TRAFFIC FORECASTING

Texas Department of Transportation

The Traffic Analysis Subsection of the Transportation Systems Planning Section was responsible for preparing forecasts of rural traffic on state highways. The only exception to this was in the Houston area, where the District office prepared the forecasts. The forecasts of rural traffic were used primarily for pavement design and, as a result, focused on forecasting truck traffic. The basic traffic data needed in the forecasting process were compiled by the Research and Development Section as part of the Department's statewide traffic data collection program. This program is described in Chapter 3.

Two basic approaches were used to forecast rural traffic: 1) Site-specific growth rates based on regression analysis of historical traffic trends from over 2300 manual count stations; and 2) countywide traffic growth rates (this approach was used if scatter in the historical data were too wide for regression analysis). Unless the district which requested the forecast provided information concerning socioeconomic data and/or special traffic generators, the forecasts were based exclusively on historical traffic trends. The basic forecasting process is outlined below.

Requests for forecasts were received from districts, other Divisions, the Highway Commission, or TxDOT Administration. The requests typically included the following information:

- A description of the project
- A map showing the beginning and ending points of the project
- The desired design years (Transportation Systems Planning Section provided the “current year plus one” as the base year and a 20-year forecast unless otherwise requested)
- Any local knowledge of the area concerning new or proposed residential and commercial developments (including any potential development that may affect historical traffic trends)

The traffic analysis addressed the following:

- Base year ADT
- Design year ADT
- Percentage trucks in ADT
- Design hour volume (DHV)
- Percentage trucks in DHV
- Directional distribution
- Average ten heaviest wheel loads daily (ATHWLD)
- Percentage tandems within ATHWLD
- Flexible KIPS
- Rigid KIPS

The base year ADT is a weighted ADT calculated from total VMT/total project length. The base ADT is calculated for the following: 1) Base ADT on existing route for the “no-build” condition; 2) base ADT on existing route for the “build” condition; and 3) base ADT on proposed route for the “build” condition. For the “build” condition, traffic is diverted from alternate routes based on previous experiences with similar projects.

Preparing forecasts of future ADTs typically involved (1) searching job files for previous forecasts (if previous forecast was available, it was used as a reference and updated, if necessary); (2) if previous forecast did not exist, looking up the forecast contained in the RI2T Log (the forecasts

in the Log were developed using either a site-specific regression model or a countywide growth rate); and (3) if the request contained information on new or proposed developments which may effect the project, using the procedures in the *Special Traffic Generator Study* (TxDOT, 1973-75) to estimate the additional traffic and adjusting the ADT estimates accordingly.

The next step in the process was to estimate the percentage trucks in the ADT. If the project had an existing manual count station, then the percentage trucks were determined directly from the historical data in the RI2T Log. If the project does not have a manual location, the analyst used professional judgment to identify another highway in the region similar to the project being analyzed and for which historical traffic data existed. (The Transportation Systems Planning Section had access to historical data for over 2,300 manual count stations for use in this part of the analysis). The resulting estimates were by truck type (e.g., light duty vehicles, medium duty vehicles, heavy duty vehicles). These classifications were also used to determine truck axle factors for the “Road Test 68 Program.”

The next step in the procedure was to use information from an appropriate permanent automatic traffic recorder (ATR) to establish the DHV, directional distribution, and percentage trucks in the DHV. Data were available from over 150 ATR sites to determine these factors. After these calculations were made and analyzed, the analyst prepared to input these variables in the Road Test 68 Program.

The Road Test 68 Program to calculated equivalent 18 KIP single-axle load applications for flexible and rigid pavement for a specified design period (usually 20 years). The program also calculated the ATHWLD and the percentage tandems within the ATHWLD.

In order for Road Test 68 to calculate the number of 18,000 pound equivalent axles for a section of road, it took the number of truck axles passing over the roadway in question and applied it to a representative “table” of actual truck weight distributions and to the “Table of Equivalency Factors” developed by AASHTO.

The actual weights of trucks at various locations in Texas were made available to Road Test 68 in a reduced form. The weights of all of the single axles and the tandem-axle sets weighed at each location were assigned to their respective weight group (e.g., all single axles weighing less than 1,000 pounds were placed in Weight Group 1, all single axles weighing between 1,000 and 2,000

pounds were placed in Group 2, etc.).

A representative weight station was selected, and Road Test 68 adjusted the distribution of single axles versus tandem axles and distributed them according to the percentage of single axles at the section of road in question.

The truck axles were distributed based on their representative weight location and converted into 18,000 pound equivalencies by application of the AASHTO factors. This gave the amount of stress for one day. This number was then expanded by multiplying by the number of days in the design period.

The calculation for the ten heaviest wheel loads was similar to the calculation of 18 KIPs. However, instead of considering the stress caused by the accumulation of all trucks, only the weights of the ten heaviest wheel loads were considered. After the ten heaviest wheel loads were established, the percentage that were tandems was calculated.

The results of the analyses were summarized and forwarded to the District/Division/Commission for review.

Other States

This section of the report presents a summary of rural traffic forecasting procedures used in other states. As suggested in an FHWA publication, the forecasting procedures reviewed in this section are presented under the following general categories: 1) trendline analysis, 2) state/regional growth factoring, and 3) regression models. Much of the background information on these basic techniques has been extracted (by permission) directly from the FHWA.

The forecasting techniques can be implemented using a calculator or simple computer program in a relatively short time and are commonly referred to as “simplified” procedures. These simplified procedures are used to develop quick, inexpensive, site-specific forecasts for use in highway (pavement) design.

The following review focuses on the basics of these simplified forecasting methods. Examples of more sophisticated, network based models for forecasting rural traffic are presented in the subsequent discussion of Intercity and Statewide Forecasting.

Trendline Analysis

Perhaps the most commonly used simplified traffic forecasting procedure is trendline analysis. This type of analysis uses historical traffic trends to develop an estimate of annual growth which is likely to occur in the future. Typically, trendline analysis is used to develop traffic forecasts for rural highways which are not part of computerized networks.

The annual growth rate used in trendline analysis is determined by a graphic process or by calculating an average growth rate from historical traffic data. If a manual, graphic process is utilized, the historical data are plotted and any historical events which may have had a bearing on growth (e.g., industrial plant relocation, construction of alternate routes, etc.) are noted. The historical data are reviewed from a reasonableness standpoint to ensure that no obvious errors are included in the data set. As an example, if one traffic count is significantly higher or lower than the rest, and there is not a plausible explanation for this anomaly, consideration should be given to excluding that count from the analysis. Various curves are drawn through the set of points, and the curve which appears to fit best should be selected. The curve is then extended through the entire forecast period and forecast values read off the curve.

An alternative process of trend analysis involves calculating average growth rates. This is accomplished by using simple linear regression analyses to fit a line through the data or by simply choosing two data points which define the most appropriate trend and calculating an average growth rate. The growth rate expressed as an average percentage is found through the use of the following equation:

$$\text{Average Percentage} = ((X_2 - X_1)/X_1N) \times 100\%$$

where:

- X_2 = final data point
- X_1 = initial data point
- N = number of years between X_1 and X_2

The resulting growth rate is then multiplied by the number of years between the most recent data point and the forecast year. This total anticipated percentage growth is then multiplied by the value of the initial data point to yield the anticipated increase or decrease. By adding the anticipated growth to the initial data value, the forecast value can be obtained.

This process is summarized in the following equation:

$$\text{Forecast Value} = [(AGP)(N_1)(X_1)] + X_1$$

where:

- AGP = average growth percentage
- N_1 = number of years between initial year and forecast year
- X_1 = initial data value

It should be noted that this growth rate is linear with a constant amount of growth assumed each year. Such a forecast might be most appropriate in a region which can support only a finite annual amount of growth. As an example, if a region's real estate market could absorb only X number of housing or office units per year but growth at this rate could be maintained during the entire forecast period, this type of trend analysis could be very appropriate.

If the historical data indicate a nonlinear growth rate, a forecast based on a compounded percentage growth may be more appropriate. The compounded growth rate is calculated with the following equation:

$$\text{Compounded Growth Rate} = (X_2/X_1)^{1/N} - 1$$

where:

- X_2 = final data point
- X_1 = initial data point
- N = number of years between X_1 and X_2

The resulting compounded growth rate is used to forecast future traffic through use of the following equation:

$$\text{Forecast Value} = (X_2)(1 + ACG)^{N_1}$$

where:

- X_2 = most recent data value
- ACG = average compounded growth rate
- N_1 = number of years between the most recent data observation and the forecast year

Caution should be used in applying compounded growth rates to long forecast periods, as compounding results in progressively larger increases in growth each succeeding year. As a result,

the use of a combination of linear and compound growth rates may be appropriate for some long-range forecasts. When preparing traffic forecasts of major improvement projects for rural highways, the Florida DOT, for example, uses a compound growth rate for the first ten years of the forecast and a linear growth rate thereafter.

Several states, including New York, Minnesota, Florida, Iowa, and Idaho, use simple traffic count trending procedures to forecast rural traffic for use in pavement design. NYSDOT recommends that application of the trending procedure be restricted to short-range (1-5 year) forecasts. Most of these procedures utilize only a single variable (e.g., traffic counts) and do not explicitly account for the effects that other factors, such as population and commercial activity, can have on future traffic growth, though several states suggest that the analyst “consider” available demographic, economic, and land use forecasts in selecting an appropriate traffic growth factor. In giving consideration to these “other factors” in trendline analyses, it is commonly suggested that the analyst use professional judgment to develop a simple or weighted average growth factor based on historical traffic growth and average population and employment growth between the base and design years. In terms of incorporating future land use changes into the forecasting process, the typical suggestion is to apply standard trip generation rates to estimate the additional traffic generated by specific developments and adjust the traffic forecast accordingly.

Though not providing quantitative guidance, the Florida DOT suggests the following additional adjustments which should be considered in developing rural traffic forecasts:

- (1) An adjustment must be applied to the historical traffic growth rate for a generation effect if the subject facility is to have lanes added.
- (2) The effect of known major land use changes must be applied both as generation and accelerated growth rate.
- (3) Traffic volume forecasts must not exceed the capacity of the ultimate facility at the subject location.

State and Regional Growth Factoring

Perhaps the simplest form of forecasting is the development of statewide or regional growth factors which can be applied to existing traffic counts in order to develop future estimates of traffic

volumes. Such a procedure is based on the assumption that all transportation facilities within a state or region will exhibit the same growth rate during the forecast period. The development of these growth factors can be based on data related to historical traffic counts, population, and other socioeconomic variables or VMT forecasts. The use of these data sources is outlined below.

The use of historical traffic data to develop regional or statewide growth factors is perhaps the most common form of this type of forecasting. By analyzing traffic counts on various facilities over the past ten to 20 years, it is possible to develop annual percentage growth rates for individual regions or the state as a whole. For example, many states find that traffic doubles in 20 years. An analysis of annual traffic counts is significantly enhanced if traffic records are computerized. In such a case, it is possible to develop average growth rates for different types of facilities (e.g., by functional classification, small urban versus rural location, or by traffic volume group).

The use of population, driver population, employment, or other types of socioeconomic variables is another means of developing regional or statewide forecasts. Since a great deal of resources are usually allocated toward forecasting these data in many states and regions, this approach may yield a better forecast than utilizing traffic counts alone, as the forecasts will not be limited to past traffic trends. In order to forecast traffic in this method, it is necessary to establish a relationship between travel and the socioeconomic variables. The analysis of past driver population trends with relationship to traffic counts, VMT, or fuel consumption can be used to identify this correlation.

The use of VMT forecasts is based on historical observations of levels of driver population, automobile ownership per driver, gasoline consumption per vehicle, vehicle miles per gallon of gasoline, and the interrelationships that may be deduced from the observed values of these variables. The basic theory is based on past experience; a given driver population will purchase automobiles/pickups up to a saturation level near one personal vehicle per driver, and each driver or vehicle will travel an average number of miles per day related to their age or activity level. This number of vehicle miles times estimated MPG rates gives fuel consumption. If the gallons of fuel sold is known, it can be used to check and add in missing through traffic, local traffic, etc. A further assumption, again based on past experience, is that specific percentages of these VMT may be allocated to the different functional systems of highways.

The application of these data to develop growth factors to forecast traffic typically consists of the following basic steps:

1. Using base year traffic counts, calculate the VMT on each functional system of the state. Calculation of percentages of VMT by subclassifications or functional class (rural, small urban area, urbanized area) would provide additional detail in the forecasts.
2. Determine the population, vehicle ownership, gasoline consumption, and MPG rates and rates existing in the base year.
3. Check to see that VMT estimates obtained from traffic counts compare reasonably well with observed gasoline consumption, MPG rates, etc., and resolve inconsistencies.
4. Obtain forecasts of future year population levels and make assumptions regarding changes in gasoline consumption rates (if any) and changes in MPG rates (if any).
5. Calculate future year VMT and VMT growth factors. These factors may be developed for each geographical area of the state disaggregated by functional class and area type.
6. Apply the VMT growth rates to the base year ADT values of the highway sections using the subclassifications employed in Step 5.

This procedure has the advantage of relating ADT forecasts to generally accepted independent estimates of population and related gasoline consumption. It has the drawback of not providing a high level of sensitivity to subregional changes in development density. Depending on the level of detail included in a growth factoring process, it is highly likely that forecasts will overlook conditions which are too localized or unique to be adequately represented by the model.

The Kentucky DOT has developed a procedure to forecast highway traffic volumes through the use of growth factors which are representative of Kentucky highways and which reflect the effects of socioeconomic and demographic variables. A two-stage modeling process is used. In the first stage, linear regression models are used to relate average daily travel on Kentucky roadways to personal income, price of fuel, and total miles of streets and highways. In the second, cross-tabulation models are used to relate growth in volume at a specific site (expressed relative to the

statewide ADT) to highway functional classification, rural/urban location, county population growth, MSA/non-MSA designation, and volume level. The growth model yields estimates not only of the most likely rate of growth at a particular site but also of the range experienced at similar sites statewide. The growth-factor model produces estimates of growth (annual compound percentage) in the volume ratio as a function of local conditions. These conditions, representative of the site during the base year, include the following: 1) development density in terms of rural/urban categorization, 2) functional classification, 3) past county population growth, and 4) volume level. In general, the procedure for forecasting future travel at a site involves estimating the rate of change in growth at the site as compared to the statewide average.

Regression Models

Multiple linear regression models have been used in transportation studies to develop travel forecasts based on a number of socioeconomic variables. The basic regression model can be expressed by:

$$Y = B_0 + B_1X_1 + B_2X_2 \dots + B_nX_n$$

where:

Y	=	Dependent variable (ADT)
X ₁ , ..., X _n	=	socioeconomic variables
B ₀ , ..., B _n	=	regression coefficients

The application of standard multiple regression techniques produces a series of multiple linear regression equations which are computed in a step-wise manner. At each step, one variable is added to the equation. The variable retained is the one which results in the greatest reduction in the sum of squared errors (providing the reduction is statistically significant). This computational procedure yields several different equations for a given dependent variable, depending on the array of independent variables examined for testing and selection. In selecting the most appropriate equation, the logic of the variables used is of prime consideration. Unless a cause-and-effect relationship can be established between a dependent and independent variable, the independent variable should not be allowed to enter the equation, regardless of its consequence upon the results.

One of the most important variables in forecasting travel is the number of people who are

able to travel, that is, licensed to drive and having access to transportation. Other variables which have a bearing on travel include:

- Household Size (the number of highway trips increases with the number of household members);
- Employment (as employment increases, so does travel);
- Income (households with greater income travel more, in part because more automobiles are available for use); and
- Gross National Product (heavy commercial travel levels have been found to be positively correlated to GNP).

Because multiple regression models are sensitive to corridor or regional land use changes, they can be much more accurate in forecasting changes in local travel levels than simple growth factoring or trendline analysis. If socioeconomic projections of an area are accurate, the forecast for travel by local residents should also be accurate. The drawback to multiple regression travel models is that while the process provides sensitivity to growth in local traffic, it limits long distance traffic (particularly through traffic) to a constant value over time. For this reason, it is often suggested that the constant terms of a multiple regression equation be readjusted for future year applications based on the results of previous forecasts, which can be judged now. The adjustments could be accomplished on an across-the-board basis or selectively by areas of the state which exhibit varying growth rates for intercity travel.

The New Mexico State Highway Department uses a linear regression procedure for forecasting heavy commercial traffic on its highway system. The New Mexico procedure uses 14 separate models to forecast heavy commercial traffic along unique sections of New Mexico's interstate system. The grouping of sections of interstate highways accounts for differences in travel on east-west and north-south highways, as well as variations in commodity movement over different stretches of the same interstate route.

After a thorough statistical analysis, four factors were determined to provide the best indicators. These include:

- United States average gasoline cost per gallon;
- United States disposable personal income;

- New Mexico population; and
- New Mexico residential building permits (dollar value).

Linear regressions were conducted using heavy commercial ADT and average daily traffic as dependent variables. Six years of historical data were used. The Statistical Analysis System (SAS) was used to conduct the multivariate analysis. Best fit equations were then used to predict heavy commercial ADT and average daily traffic from 1985 to 2005. These forecasts are used primarily in pavement design and analyses.

Regression techniques can also be used to develop elasticity equations which relate future traffic to present year traffic through changes in several socioeconomic variables. The general form of the elasticity model is as follows:

$$AADT_f = AADT_p \{1.0 + e_1 [(X_{1,f} - X_{1,p})/X_{1,p}] + \dots\}$$

where:

$AADT_f$	=	AADT in the future year,
$AADT_p$	=	AADT in the present year,
$X_{1,f}$	=	value of variable X_1 in the future year,
$X_{1,p}$	=	value of variable X_1 in the present year,
e_1	=	elasticity of AADT with respect to X_1 .

It can be shown that given an equation of the form:

$$Y = a + a_1X_1 + a_2X_2 + \dots + a_nX_n$$

Elasticity measures can be estimated by:

$$e_i = a_i (X_i/Y)$$

Thus the socioeconomic factors that best estimate AADT, and their respective elasticities, can be derived by using multiple linear regression.

An elasticity model has a number of potential advantages. First, elasticity models are generally believed to have a range of accuracy in excess of the range of traffic volumes that are used in the calibration data set. The reasoning behind this belief is that elasticity forecasts rely on a discovered relationship of underlying variables which generate traffic rather than on a simplistic review of past traffic growth. Second, the use of present year traffic patterns in estimating future year

traffic levels reduces the concern about underestimating nonresident travel. For better or worse, nonresident travel will be expected to grow at a similar rate as resident travel under this model. Finally, the elasticity portion of the model calculates a growth factor directly so the procedure can be easily transformed into a set of nomographs which simplify and expand this method's use in forecasting.

The elasticity approach to forecasting alleviates some of the shortcomings of a multiple regression model. However, like every model which relies on forecast socioeconomic data for input, the accuracy of the model is determined to a large degree by the accuracy of the input. Care should be exercised in selecting logical input variables which are regularly forecast at state, county, and local levels. Finally, this model contains the underlying assumption that elasticities are constant over time. Significant long-term changes in travel behavior would, of course, invalidate this model, requiring at least recalibration.

The process of developing elasticity equations which can be used for travel forecasts was pioneered by the New York State Department of Transportation during the 1970s and 1980s. The elasticities and appropriate socioeconomic variables are identified through a series of linear analyses which relate AADT to a variety of local, county, and statewide factors. Historical traffic counts were collected over a five-year period at a number of rural count stations. These counts were supplemented with data from state, county, and town levels on population, households, automobile ownership, and employment for the same years.

Using these data, trial and error type regression analyses were employed to develop multiple-variable linear equations and the estimates of their elasticities. In recognition of differing travel patterns, three classes of roads were utilized. These road classes were based on the functional classifications of interstates, principal arterials, and the combination of minor arterials and major collectors. Three sets of elasticities and forecasting models were developed, one for each class of road. The final NYSDOT equations for rural highways are summarized below:

$$\text{AADT}_f(\text{Interstates}) = \text{AADT}_p [1 + 0.228 (\% \text{ change in county autos}) + 0.832 (\% \text{ change in town households})]$$

$$\text{AADT}_f(\text{Principal Arterials}) = \text{AADT}_p [1 + 0.572 (\% \text{ change in county households}) + 0.670 (\% \text{ change in town population})]$$

$$\text{AADT}_f(\text{Minor Arterials}) = \text{AADT}_p [1 + 0.314 (\% \text{ change in town households})]$$

The NYSDOT has extended this elasticity-based approach to obtain estimates of future traffic at urban project sites. The Indiana DOT has also developed elasticity-based models (similar to the NYSDOT models) to forecast future traffic on the state's rural highways.

Discussion

Unlike the computer modeling programs used for urban travel demand modeling, procedures for forecasting traffic for individual rural roads are very simplistic. Most rural traffic forecasting procedures use growth rates based on historical traffic data and professional judgment concerning the effects of population, land use, and economic trends.

Given the relatively slow, uniform traffic growth rates experienced on most rural highways, it can be argued that these simple trending procedures are entirely appropriate for forecasting total traffic volumes on rural roadways. However, because rural traffic forecasts are frequently used for pavement design, rural traffic forecasting procedures need to be refined in the area of truck traffic forecasting. There is also a need to account for the effects of land use and sociodemographic changes on traffic growth in a systematic and objective manner. These two areas (truck forecasting and effects of land use changes) were specifically identified by TxDOT staff as areas where the Department's rural traffic forecasting procedures are in need of improvement.

Research Report 1235-1 addresses truck traffic forecasting procedures. That report, in conjunction with improvements in the Department's WIM and vehicle classification data collection programs, provides the basis for upgrading TxDOT's truck traffic forecasting capabilities.

With regard to incorporating population, land use, and economic considerations into the rural traffic forecasting process, the following research efforts were recommended:

- (1) Develop elasticity equations (models) which relate future rural traffic to present traffic through changes in socioeconomic variables. The elasticities and forecasting models developed by NYSDOT provide a useful point of departure for research in this area.
- (2) Review/update the Department's Special Traffic Generator Study (1973-75). The land use classifications and trip generation rates should be reviewed and updated

where appropriate.

A final area where it may be possible to improve the Department's rural traffic forecasting procedures is in estimating the amount of traffic that would divert from alternate routes to new or improved rural highways. Department practice was to estimate diverted traffic based on "previous experiences with similar projects." It is recommended that the Department consider developing more rigorous standards and procedures for estimating the traffic diversion potentials of new or improved rural highways. In this regard, the development of traffic diversion curves based on travel time ratios should be evaluated.

INTERCITY AND STATEWIDE TRAFFIC FORECASTING

Texas Department of Transportation

The Transportation Systems Planning Subsection of the Transportation Systems Planning Section conducted intercity route studies. The responsibility for intercity highway traffic analysis and forecasting rested with the Traffic Analysis Subsection. The rural traffic forecasting procedures described in the previous section of this Chapter were also used in conducting intercity highway studies. These studies were conducted in response to requests brought before the Texas Transportation Commission or in response to directives received from TxDOT Administration.

The Transportation Systems Planning Section distinguished between two types of intercity highway studies: 1) route studies (new facility/new alignment) and 2) feasibility studies (upgrading an existing facility). The basic steps in conducting these studies were: 1) meeting with the appropriate District-level personnel to discuss the study; 2) conducting field reviews of proposed route; 3) compiling cost estimates; 4) for route studies (new facility/new alignment), determining alignment (District responsibility); and 5) preparing project report.

Efforts to develop a State Highway Plan (State Highway Trunk System) resulted in substantial changes in the Department's approach to intercity route studies. These changes are outlined below. Prior to discussing the Department's statewide planning efforts, however, it is useful to review the procedures used by the Department in the past to conduct intercity route studies.

In assessing the need for new or upgraded intercity highways, the Transportation Systems Planning Section considered the following factors: projected traffic volumes and level of service;

population trends; land use; economic development; and safety. While factors other than traffic volume were considered, these other factors (i.e., population, land use, and economic development) were not incorporated directly into the final project evaluation process. For example, intercity highway study documents typically include a summary of historical and projected population in the study corridor and inventory of significant/sensitive land uses and a brief discussion of the potential linkages between highway investments and economic development. In the final analysis, the feasibility of intercity highway projects was assessed on the basis of cost per vehicle miles traveled. The specific cost-effectiveness indices varied by project type, as outlined below.

- Capacity Increase Projects (e.g., expansion of existing cross-section from two-lanes to four-lanes) were evaluated on the basis of a Congestion Relief Index (CRI). This method assumed base year average daily traffic and was calculated by dividing the total costs (cost of construction and right of way) by existing traffic in excess of Level of Service C-D plus latent traffic demand times the length of the project, as shown below:

$$CRI = \frac{\text{Construction + Right of Way Cost}}{(\text{Existing Traffic} > \text{Level C-D} + \text{Latent Demand}) (\text{Length})}$$

The level of service threshold volumes used by the Department in these analyses are shown in Table 15. The “latent demand” term, the denominator, was calculated from the following equation. This equation was estimated by using the Department’s traffic assignment models to calculate the additional traffic volume that would result from various added capacity scenarios.

$$LD = 5 + 0.126 (VOL1) + 3170 (VC1) + 3945 (FWY) + 0.231 (CDIF) - 0.177 (CAP2)$$

where:

- LD = latent demand
- VOL1 = base year traffic (ADT)
- VC1 = base year V/C ratio
- FWY = facility type (1 = Freeway, 0 = Non-freeway)
- CDIF = increase in capacity (ADT)
- CAP2 = roadway capacity after improvement

- New Location Projects were evaluated on a cost per vehicle-mile (C/VM) basis. This

method assumed base year average daily traffic and was calculated by dividing the total costs (cost of construction and right of way) by the existing traffic times the length of the project, as shown below:

$$C/VM = \frac{\text{Construction + Right of Way Costs}}{(\text{Existing Traffic}) (\text{Length})}$$

The Department used a threshold value of \$400/vehicle-mile for identifying cost-effective new location projects. This threshold value was used to select projects in the 10-Year Project Development Plan.

Table 15
Level of Service Traffic Volume Ranges (ADT) by Highway Class
TxDOT

Highway Class	Range in ADT Service Volumes		
	LOS A-B	LOS C-D	LOS E (Capacity)
Urban Freeways:			
4 Lane	0 - 44,000	44,001 - 52,800	52,801 - 64,400
6 Lane	0 - 66,000	66,001 - 79,200	79,201 - 96,600
8 Lane	0 - 88,000	88,001 - 105,600	105,601 - 128,800
Each Additional Lane	0 - 11,000	11,001 - 13,200	13,201 - 16,100
Urban Divided Streets ^{a,b}			
4 lane	0 - 16,100	16,101 - 19,100	19,101 - 23,000
6 Lane	0 - 23,500	23,501 - 27,900	27,901 - 33,000
8 Lane	0 - 29,400	29,401 - 34,900	34,901 - 42,000
Urban Undivided Streets ^{a,b}			
2 Lane	0 - 16,100	7,701 - 9,100	9,101 - 11,000
4 Lane	0 - 12,600	12,601 - 14,900	14,901 - 18,000
6 Lane	0 - 19,800	19,801 - 23,500	23,501 - 28,300
Rural Freeways			
4 Lane	0 - 20,800	20,801 - 31,600	31,601 - 42,000
6 Lane	0 - 31,200	31,201 - 47,400	47,401 - 63,000
Rural Divided Highways ^{a,b}			
4 Lane	0 - 12,000	12,001 - 17,500	17,501 - 35,000
6 Lane	0 - 18,000	18,001 - 26,200	26,201 - 52,500
Rural Undivided Highways ^{a,b}			
Rolling Terrain, 2 Lane	0 - 2,800	2,801 - 4,700	4,701 - 14,700
Level Terrain, 2 Lane	0 - 3,700	3,701 - 6,100 ^c	6,101 - 17,400
4 Lane	0 - 9,500	9,501 - 13,000	13,001 - 26,000
6 Lane	0 - 15,000	15,001 - 19,500	19,501 - 39,000

^a A “divided” facility includes a flush or depressed median with sufficient width for storage of left-turning vehicles. On “undivided” facilities, left turns are made from a through lane.

^b “Urban street” as opposed to “rural highway” conditions prevail whenever the intensity of roadside development, speed zoning, signals, stop/yield signs, etc., result in interrupted flow conditions and reduced traffic speeds.

^c Used as limiting value for tolerable flow for all 2-lane roadways (urban and rural operation) in 10-Year Project Development Plan except for rural rolling terrain.

- New Loop and Bypass Projects were evaluated on a cost per vehicle-mile (C/VM) basis. This method assumed base year traffic and was calculated by dividing the total costs (cost of construction and right of way) by the length of the project times the existing average daily traffic volume adjusted for truck equivalency (2.4 passenger cars per truck), as shown below:

$$C/VM \text{ (New Loop/Bypass)} = \frac{\text{Construction} + \text{Right of Way Costs}}{(\text{Existing Traffic} + \text{Truck Equiv.}) (\text{Length})}$$

The Department used a threshold value of \$600/vehicle-mile to identify cost-effective bypass projects. This value was used to select loop/bypass projects in the 10-Year Project Development Plan.

- Principal Arterial System Gap Projects were evaluated on a cost per vehicle-mile (C/VM) basis. This method assumed base year traffic and was calculated by dividing the total costs (cost of construction and right of way) by the length of the project times the existing average daily traffic volume, as shown below:

$$C/VM \text{ (Gap)} = \frac{\text{Construction} + \text{Right of Way Costs}}{(\text{Existing Traffic}) (\text{Length})}$$

The department used a threshold value of \$350/vehicle-mile to identify cost-effective arterial system projects. This threshold value was used to select projects in the 10-Year Project Development Plan.

In addition to the cost-effectiveness indices described above, the Department also utilized the Highway Economic Evaluation Model (HEEM) to calculate benefit/cost ratios for each proposed highway improvement. Data on values of time, vehicle operating costs, accident costs, maintenance costs, traffic and truck volumes, type of existing and proposed highway facilities, and construction and right-of-way costs were used in HEEM to determine the most cost-effective alternative.

In the past, the Department's intercity route studies were conducted on a route-by-route (site-specific) basis. The Department developed a Statewide Highway Trunk System Plan, and intercity route planning has become more system oriented.

The objective of the Texas Highway Trunk System Plan was to develop a rural network of four-lane or better divided roadways that would serve as the principal connectors of urban areas in

the state, as well as major ports and points of entry from surrounding states and Mexico. The development of this rural highway network stressed connectivity and was not based on a comprehensive analysis of statewide traffic demands and travel patterns.

The basic highway trunk system was developed by partitioning the state into six population classes and “connecting” these classes according to the following priorities:

1. Connect cities in the 1 million+ population class to each other. These cities are already connected via the existing Interstate Highway System.
2. Connect counties in the 300,000+ population class to cities in the 1 million+ class.
3. Connect counties within the 300,000+ population class to each other.
4. Connect counties in the 100,000+ class to the cities in the 1 million+ class.
5. Connect counties in the 100,000+ class to the 300,000+ class counties.
6. Connect counties in the 50,000+ class to the 1 million+ class cities.
7. Connect counties in the 25,000+ class to the system via the shortest connection.
8. Other considerations:
 - a. Cities greater than 10,000 not previously served.
 - b. All deep water ports.
 - c. All significant military installations.
 - d. All international bridges with 5,000+ ADT.
 - e. Significant recreational areas.
 - f. Connection to adjacent out of state cities in 1 million+ population class.

In order to make maximum use of existing facilities, a 20 percent circuitry allowance was used in establishing the individual connections enumerated above.

The resulting State Highway Trunk System would consist of over 11,000 miles of four-lane divided highways. Nearly 50 percent of the system will be new or upgraded facilities.

Other States

Intercity highway studies can be conducted for isolated, individual routes using the simplified, manual, rural traffic forecasting procedures outlined earlier in this chapter; or they can be conducted using system-level, network-based computer models. Practices for conducting intercity

highway studies for isolated roadway links do not differ substantially from state to state, though the relative sophistication of specific traffic forecasting procedures may vary, as indicated in the preceding review of rural traffic procedures.

A number of states have developed, or are in the process of developing, statewide traffic forecasting models. Typically, these efforts involve expanding the familiar mainframe computer-based urban network models to stateside applications. In the area of statewide travel demand modeling, the efforts of Michigan, Kentucky, and Wisconsin are particularly noteworthy. The following examples provide a representative overview of the state-of-the-practice in statewide travel demand modeling. Much of the following material was extracted directly from materials provided by the respective states.

The Michigan Department of Transportation developed a customized mainframe based statewide travel forecasting model that incorporated all urban and rural trunkline highways in the state. Intercity travel generated from the many urban corridor studies conducted over the years. Intrazonal travel is not generated, however.

This program, called the Statewide Strategic Transportation Modeling System, uses four distinct sources of data for the model. The first major class of information is commonly referred to as facility file data. This information identifies places of specified activity such as airports, hospitals, and state parks.

The second major class of information used in the model is the transportation network. In Michigan, seven transportation networks were defined: highway, rail, bus, air, electric, gas, and oil. All of these networks are defined using the link concept so that one set of procedures can be applied to several modes.

The third major class of information is socioeconomic data. These data include population, income, employment, housing, and retail trade. This information is summarized by traffic analysis zone. In Michigan, two zone systems were developed. One system has the state divided into 508 zones and also uses another 39 zones to represent external zones outside Michigan. The second system encompasses a total of 2,300 zones which are subdivisions of the 547 zone system. (The models within the 2,300-zone system have not been calibrated recently and, as a result, the 2,300 zone system is not used in the state's statewide travel demand modeling efforts.)

The fourth major class of information is origin-destination data. This information includes both freight and passenger movements for highway, air, rail and bus. All of this information is organized around the zone concept and includes primarily trip purpose and vehicle type information.

The Michigan model forecasts ADT and design hour volumes (DHV). The trip generation models use zone population and “external ring” population (population within 30 minutes of each zone) to estimate general purpose auto trips (all trip purposes except vacation trips) and heavy truck trips. Base year vacation trips are estimated using data from samples of Michigan and out-of-state vacationers. Vacation trips are forecast using growth rates derived from historical vacation trip data. The trip generation equations for general and heavy truck trips are given below.

$$\text{General Trips (excluding vacation trips)} = 1.04 P_c \left(\frac{0.89 P_c + P_e^{0.19}}{P_c} \right)$$

$$\text{Heavy Truck Trips} = 0.062 P_c \left(\frac{0.89 P_c + P_e^{0.11}}{P_c} \right)$$

where:

P_c = zone population

P_e = population in external ring (within 30 minutes of zone)

The trip distribution model employs separate “deterrence” (impedance) curves derived from origin-destination data for the individual purposes of travel of (1) general traffic, (2) heavy truck traffic, and (3) vacation. With the exception of vacation trips, these curves are in the form of quadratic equations which describe deterrence as a function of distance.

Traffic assignment in the Michigan model is performed using a basic iterative capacity restraint procedure. Limited error checking of model assignments on a set of links having permanent traffic recorder stations indicated that the model is biased toward over-assignment by approximately 57 percent. A simple scaling adjustment compensated for this bias, resulting in an average

assignment error of approximately 40 percent over link volumes ranging from under 1,000 ADT to 30,000 ADT.

The Michigan model has been used successfully to forecast statewide traffic volumes as well as to perform a host of other transportation planning applications, including development of an arterial trunk analysis, the conduct of a statewide average trip length analysis, and a commercial traffic weight station study. One example which illustrates the range of uses of the program was the emergency medical service analysis. Using highway and geographic data, the model was able to identify all areas of the state which could be served by various ambulance facilities. Specifically, the model was used to identify the number of ambulance facilities within 20 minutes of each zone in the state.

The development of the Kentucky Statewide Traffic Model in the early 1970s was patterned after the traditional approach to urban travel demand modeling and consisted of the following seven phases: (1) zone and network structure, (2) travel surveys, (3) trip generation, (4) trip distribution, (5) trip assignment, (6) analysis, and (7) applications.

A total of 663 zones was formed corresponding to the census county divisions and aggregation of traffic analysis units in rural and urban areas, respectively. Major recreational areas in the state (such as state and national parks, historic sites, and other major traffic generators) were treated as independent zones. Similarly, a total of 118 out-of-state zones were developed, taking a single county or combination of two or more counties in the adjacent states and a single state or combination of states for the rest of the nation. Nine screenlines were formed to check the assignments by using natural or artificial barriers depending upon the location. The in-state network contains about 11,000 miles (approximately 17 percent of the total mileage in the state).

Three types of surveys were conducted to determine the travel characteristics. Roadside origin-destination surveys were conducted on the cordon line and at certain internal area locations on a sampling basis ranging from 25 to 33 percent. The sampling data collected represent about 95 percent of the total volume of traffic crossing the cordon line. Roadside origin-destination data collected by other metropolitan agencies in the state were used to avoid duplication in collecting the data. Data collected in years other than the base year were used after proper factoring.

A household travel survey was conducted by mailing questionnaires to the in-state auto-

owning households. The sample size was 1 percent, and the usable response rate was 44 percent.

A truck travel survey was conducted by mailing questionnaires to truck registrants (1 percent sample). The usable response rate from this survey was 49 percent.

The results of the analysis of the household travel survey data showed that the best trip generation models resulted when the data were stratified by population density at the zonal level. The in-state zones were aggregated into five strata according to the population density, and trip rates were computed per household by level of auto ownership. The statewide average trip rate per household as obtained from raw survey data was 5.65. The trip rate after adjustment for income bias was 5.33, due to a high response rate from higher income households. After adjusting for VMT count/load ratio, the trip rate was 5.04, due to a slight over-assignment problem experienced on the network links. Program PRODUCTION computes the total trips produced in each zone by taking the auto-owning households in accordance with the level of ownership and the appropriate trip rate. The trips were further split into long and short trips. Trips greater than 35 minutes were designated as long trips and those less than 35 minutes as short trips.

Auto trips were distributed according to the long and short trip concept reported in NCHRP Report 70 (Social and Economic Factors Affecting Intercity Travel, 1969). Long auto trips are distributed by the "Long Trip Distribution Model." This model is somewhat similar to the Intervening Opportunity Model. It uses a production-attraction ratio at the zonal level as determined from survey sources (External origin-destination and household travel survey) and distributes the trips in relative proportion to the production area size, attraction area size, and time range rings in minutes. Internal auto short trips were distributed by a gravity model. Zonal attractions for the gravity model are obtained from program ATTRACTION. This program uses a regression model with zonal population and employment as independent variables to determine attractions based on population density strata. Very high friction factors ranging from 1,200 to 200,000 had to be used for proper distribution of auto short trips by the gravity model at the statewide level. Internal-external, external-internal auto short trips and the total truck trips are distributed by a FRATAR model. Total population/employment growth factors and industrial/commercial employment growth factors are used to distribute the auto short trips and truck trips, respectively. The base year truck trip table was developed from the following three data sources: truck travel survey, external roadside

origin-destination survey, and origin-destination data from the 19 urban area transportation planning studies that are located across the state.

The minimum time path technique, with observed speed as impedance, was used to assign trips to the appropriate network. Other methods were tested extensively, but these methods did not produce improved assignments at the statewide level. The Commonwealth of Kentucky has an excellent system of parkways. Hence, the monetary value of tolls for autos and trucks had to be converted into time to account for appropriate toll impedance. Therefore, two networks were developed reflecting appropriate travel speed and toll impedances for assignment of auto and truck trips, respectively.

The Kentucky Statewide Traffic model has been used in the following applications: determining effects of interchange locations on free and toll facilities; determining turning volumes; extending existing facilities; analyzing forecast traffic on newly proposed facilities in the absence of origin-destination data; locating bypasses; conducting other studies such as “Future Financing of Highways in Kentucky;” determining pollution emission indices for the Department for Natural Resources; determining the areas of communication influence for the Department of Tourism; and analyzing accessibility for airports, health care centers, Interstates, and parkways. Statewide Traffic Model results have also been used to provide technical assistance to other agencies in the form of travel time, distance, vehicle occupancy, trip generation rates, and total and recreational traffic volume crossing selected corridors.

WIDOT has also developed a statewide traffic model. Like the Michigan and Kentucky models, the Wisconsin model is an expansion of a UTPS-based modeling system to a statewide application. The model can forecast statewide auto, recreational, and light and heavy truck demands.

The model has been used to develop a statewide highway plan (the “Corridors 2020 Plan”). The plan proposes a 3,200-mile Corridors 2020 network comprised of two elements: a multilane backbone system and a two- and four-lane connector system. The backbone system is a 1,650-mile network of multilane divided highways interconnecting all regions and major population and economic centers in the state and tying them to the national transportation network. Today, 1,100 miles of highway identified as part of the backbone system are already multilane facilities, with another 550 left to be built. The connector system is a 1,550 mile network of high-quality highways

directly linking other significant economic and tourism centers to the backbone network. About 420 miles (over 25 percent) of the connector system will need to be multilane divided highways by 2020.

The Wisconsin Statewide Traffic Model was recently expanded by incorporating a set of interacting economic analysis models and techniques that can be used to evaluate alternative highway network configurations in terms of potential for greater business expansion, new business attraction, and tourism, as well as auto passenger user benefits. This integrated design of the traffic and economic model system is noteworthy in several aspects. A highway network model can be used to estimate impacts on traffic, distribution, and travel times. These travel time changes are then input into the economic simulation model to estimate long-term impacts on population and employment growth. The forecast changes in population and employment are, in turn, used to estimate future changes in passenger and truck traffic for the highway model. This ability for interplay of the traffic and economic models provided a means for ensuring consistency and recognizing interrelationships between traffic and business growth impacts.

Discussion

The review of TxDOT's practices in intercity and statewide traffic forecasting procedures identified several specific areas where these practices could be improved. The review of practices in several other states suggests the general nature of basic improvements TxDOT should consider.

TxDOT staff suggested that if the following capabilities were available, the Transportation Systems Planning Section's intercity and statewide traffic forecasting practices would be improved substantially:

- (1) Procedures for determining statewide travel (origin-destination) patterns particularly in the area of commercial vehicle, recreational, and military travel patterns and needs.
- (2) Improved procedures for incorporating factors other than traffic volumes into intercity and statewide highway planning projects. Specific concerns include the need to incorporate economic development impacts and "gravity model" (distance) considerations into intercity and statewide highway planning projects.
- (3) Procedures for developing emergency/natural disaster (i.e., hurricane) evacuation plans.

- (4) Procedures for system-level evaluation and prioritization of alternative corridor and statewide highway plans.

These basic concerns clearly indicate the need to investigate the development of a statewide traffic forecasting model for Texas. Experiences in other states indicate that statewide travel models can be useful planning tools. However, experiences in other states also indicate that it is important to maintain a realistic viewpoint concerning the cost, accuracy, and application of these models. Obviously, the data (and associated costs) needed to develop and maintain statewide traffic models can be considerable. As a result, most statewide models employ very coarse zone and network structures and have not been updated (recalibrated) in over ten years. Several states, including Kentucky, developed statewide models but were unable to continue the level of effort needed to maintain the models.

In terms of application, most practitioners recommend using statewide models to evaluate alternative network configurations rather than forecasting traffic demands for an individual facility.

SUMMARY

This chapter has presented a review of practices in rural, intercity, and statewide traffic forecasting procedures. The review suggests that some of the Department's concerns could be addressed through the development of a statewide traffic model. In addition, the Department should consider initiating investigations into the following areas:

- (1) Developing elasticity (and/or similar) models which relate future rural traffic to changes in socioeconomic and demographic variables.
- (2) Reviewing/updating the Department's Special Traffic Generator Study to account for the effects of proposed land use changes on rural traffic.
- (3) Reviewing/upgrading the Department's heavy truck traffic forecasting procedures.
- (4) Developing procedures for estimating the traffic diversion potential of new or improved intercity highways.
- (5) Developing procedures and/or guidelines for estimating the economic development impacts of highway expenditures.

The implications of these recommendations are significant, particularly in the area of data

collection. As noted in previous chapters, most states (including Texas) have extensive traffic data collection programs. Most states (including Texas) however, do not have comparably extensive data collection programs for travel demand modeling. It is highly likely that the feasibility of improving the Department's traffic forecasting capabilities (rural and urban) will hinge on the feasibility of implementing a comprehensive travel demand data collection program.